Chapter 15

Northern Lake Michigan Coastal Ecological Landscape

Where to Find the Publication

The Wisconsin DNR's *Ecological Landscapes of Wisconsin* publication is available online, in CD format, and in limited quantities as a hard copy. Individual chapters are available for download in PDF format through the DNR website (http://dnr.wi.gov/, keyword "landscapes"). The introductory chapters (Part 1) and supporting materials (Part 3) should be downloaded along with individual ecological landscape chapters to aid in understanding and using the ecological landscape chapters. In addition to containing the full chapter of each ecological landscape, the website highlights key information such as the ecological landscape at a glance, Species of Greatest Conservation Need, natural community management opportunities, general management opportunities, and ecological landscape and Landtype Association maps (Appendix K of each ecological landscape chapter). These web pages are meant to be dynamic and were designed to work in close association with materials from the Wisconsin Wildlife Action Plan as well as information on Wisconsin's natural communities from the Wisconsin Natural Heritage Inventory Program.

If you have a need for a CD or paper copy of this book, you may request one from Dreux Watermolen, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.

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Cover Photos

Top left: *Dwarf lake iris (U.S. Threatened) is a Great Lakes endemic restricted in Wisconsin to semi-open, calcareous habitats in a few northeastern counties. Photo by Drew Feldkirchner, Wisconsin DNR.*

Bottom left: *Seagull Bar, a sandspit at the mouth of the Menominee River near the city of Marinette, partially encloses coastal marsh vegetation. Marinette County. Photo by Wisconsin DNR staff.*

Top right: *Extensive wetlands of marsh and meadow at the Peshtigo River delta, near Lake Michigan. Marinette County. Photo by Emmet Judziewicz.*

Center right: *Great Lakes Alkaline Rockshore and Boreal Forest. Moonlight Bay Bedrock Beach State Natural Area, Door County. Photo by Eric Epstein, Wisconsin DNR.*

Bottom right: *Complex ridge-and-swales landforms occur only along the Great Lakes coasts. Wetlands of many kinds may occupy the wet swales, while coniferous forests often occur on the narrow sandy ridges. Here a linear Northern Sedge Meadow is flanked by Boreal Forest. Baileys Harbor, Door County. Photo by Eric Epstein, Wisconsin DNR.*

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Size

2,004 square miles (1,282,877 acres), representing 3.6% of the land area of the state of Wisconsin.

Climate

Cold winters and warm summers are moderated by the thermal mass of Lake Michigan, especially in coastal areas. The mean growing season is 140 days, mean annual temperature is 42.8°F, mean annual precipitation is 32.1 inches, and mean annual snowfall is 46 inches. Lake effect snow can be significant, especially along Lake Michigan. Rainfall and growing degree days are adequate to support agricultural row crops, small grains, hay, and pastures. Warmer temperatures near Lake Michigan in fall and early winter and slightly cooler temperatures during spring and early summer are favorable for growing cherries, apples, and other fruits on the Door Peninsula.

Bedrock

The Northern Lake Michigan Coastal Ecological Landscape is primarily underlain by Silurian dolomite but with some sandstone and igneous and metamorphic rocks. Generally, the land is covered by a layer of soils of glacial origin; in some places, such as on the Door Peninsula and in the Grand Traverse Islands, the depth to bedrock is only a few feet or less from the surface.

Geology and Landforms

The Niagara Escarpment is a prominent bedrock ridge of Silurian dolomite that is exposed as cliffs and ledges along the western edge of the Door Peninsula and in the Grand Traverse Islands. The same bedrock is also exposed at many locations along the east side of the northern Door Peninsula, where it forms broad, nearly level bedrock shorelines. A broad, level lacustrine plain occurs in areas bordering the west shore of Green Bay, where an extensive delta has been created at the mouth of the Peshtigo River. Landforms along the Lake Michigan shore include beaches, dunes, baymouth bars, and complex ridge-and-swale topography. Embayment lakes and freshwater estuaries are also characteristic of the Lake Michigan shore. Elsewhere in this ecological landscape, ground moraine is the dominant landform.

Soils

Soils are diverse; in some areas, lacustrine sands are found overlying clays or bedrock, which is within a few feet of the surface. On the Door Peninsula, soils are calcareous, typically stony loamy sands to loams. Shallow soils and exposures of dolomite bedrock are frequent near the Lake Michigan and Green Bay coasts. Poorly drained sands are common in the lake plain west of Green Bay and in depressions between dunes and beach ridges. Beyond the lake plain west of Green Bay, the ground moraine is composed mostly of moderately well-drained, rocky sandy loams, interspersed with lacustrine sands and clays. Peats and mucks are common along the west shore of Green Bay and in the northwestern part of the ecological landscape. There is an area of sandy soils between Stiles and Oconto Falls west of Green Bay. Chambers Island has sandy, gravelly, and clayey soils.

Hydrology

Lake Michigan is cold, deep, oligotrophic, and relatively clean; Green Bay, an estuary that is also the largest bay on Lake Michigan, is warm, shallow, productive, and dynamic. It has been heavily polluted, especially by industries that formerly dumped wastes into the Fox River at the head of the bay (which is within the Central Lake Michigan Coastal Ecological Landscape). The larger rivers that flow through this ecological landscape into Green Bay include the Menominee, Oconto, Peshtigo, and Pensaukee. These rivers and their tributaries drain the uplands west of Green Bay before passing through the extensive wetlands along Green Bay's west shore. Several large embayment lakes (e.g., Clark, Europe, and Kangaroo lakes) occur along the east side of the northern Door Peninsula. There are few large inland lakes. Several impoundments constructed on rivers west of Green Bay had been subjected to high levels of pollution from past industrial activity. On the Door Peninsula there have been serious

groundwater contamination problems from agricultural pesticides and manure. These pollutants were able to reach the groundwater through the fractured dolomite bedrock. The lower Wolf River drains the westernmost part of this ecological landscape.

Current Land Cover

Historically, the uplands were almost entirely covered by forest. Today more than 64% is nonforested. Most of this land is now in agricultural crops (51%), with smaller amounts of grassland (5.6%), nonforested wetlands (6.1%), shrubland 0.1%), and urbanized areas (0.8%). The most abundant cover type in the forested uplands (262,119 acres or 20.4% of the ecological landscape) is maple-basswood, with smaller amounts of aspen-birch. Forested wetlands (mostly lowland hardwoods, with some conifer swamps) cover slightly over 14% of the area. Other cover types are comparatively scarce but of high importance ecologically and include maple-beech, hemlock-hardwoods, white pine, and mixtures of boreal conifers (dominants include white spruce-balsam fir-white pine-white cedar). Important nonforested wetland communities include marsh, sedge meadow, and shrub swamp.

Socioeconomic Conditions

The counties included in this socioeconomic region are Marinette, Oconto, Shawano, and Door counties.

Population

149,143; 2.6% of the state total.

Population Density

40 persons per square mile

Per Capita Income

$29,661

Important Economic Sectors

The largest employment sectors in 2007 were the Tourism-related (14.4%), Manufacturing (non-wood) (13.4%), Government (12.5%), and Retail Trade (9.3%) sectors. Although forestry, agriculture, and development do not have as large an impact on the economy or in the number of jobs they produce, they are the sectors that have the largest impact on the natural resources in the ecological landscape.

Public Ownership

Only about 3.5% of the Northern Lake Michigan Coastal Ecological Landscape is public land. Some smaller islands are managed by the U.S. Fish and Wildlife Service for colonial nesting birds as part of the National Wildlife Refuge System. State ownership includes five state parks—four on the Door Peninsula and one in the Grand Traverse Islands—as well as lands administered and/or managed by the Wisconsin DNR's Wildlife Management, Fisheries, and State Natural Areas programs. Door County Parks System owns several ecologically significant tracts along the Green Bay and Lake Michigan shores. An extensive area of county forest (Marinette and Oconto counties) occurs near the Green Bay west shore, and another is in the sandy area in Oconto County along the Oconto River. A map showing public land ownership (county, state, and federal) and private lands enrolled in the Forest Tax Programs in this ecological landscape can be found in Appendix 15.K at the end of this chapter.

Other Notable Ownerships

The Wisconsin Chapter of The Nature Conservancy has a major conservation project on the Door Peninsula. There are several Land Trusts active in this area, and the Door County Land Trust has a number of active projects.

Considerations for Planning and Management

The ecosystems of Lake Michigan, Green Bay, and the Green Bay west shore wetlands have changed dramatically in a short period of just a few years in recent decades. Conservation plans must be highly adaptive, coordinated, and integrated. Increasing development, skyrocketing land prices, and increasing recreational pressure on a limited land base are placing serious constraints on conservation efforts on the Door Peninsula. Pollutants in Green Bay have created serious management problems, especially for fish and fish-eating birds, and by extension, potentially for humans. The

Emma Toft was an early and effective conservationist active in the protection of botanically rich sites such as The Ridges Sanctuary and Toft Point. Photo by Wisconsin DNR staff.

Mike Grimm, director of The Nature Conservancy's Sturgeon Bay office (on right), and Wisconsin DNR ecologist Eric Epstein at North Bay, an extensive coastal wetland complex of sedge meadow, marsh, fen, and conifer swamp. Northeastern Door Peninsula. Photo by Drew Feldkirchner, Wisconsin DNR.

shallow soils and fractured bedrock of the Door Peninsula and Grand Traverse Islands makes sustainable development and water management challenging and expensive. The rapid spread of invasive species over the past several decades is overwhelming managers and agency budgets and is exacerbated by the large number and high mobility of visitors (including tourists and commercial ships from other parts of the world), especially to the Door Peninsula, Grand Traverse Islands, and Green Bay west shore. Browse pressure from high populations of white-tailed deer is having negative impacts on many of the native ecosystems and plant communities in this ecological landscape, especially on the biologically diverse Door Peninsula.

Management Opportunities

The Northern Lake Michigan Coastal Ecological Landscape borders Lake Michigan and Green Bay, encompassing over 200 miles of Great Lakes coast. The shorelines and related habitats, some of them unique to the Great Lakes, are used during the spring and fall by large numbers of migratory birds. In recent years, tens of thousands of diving ducks have been recorded wintering in offshore Lake Michigan habitats. Both Lake Michigan and Green Bay are highly significant for fish.

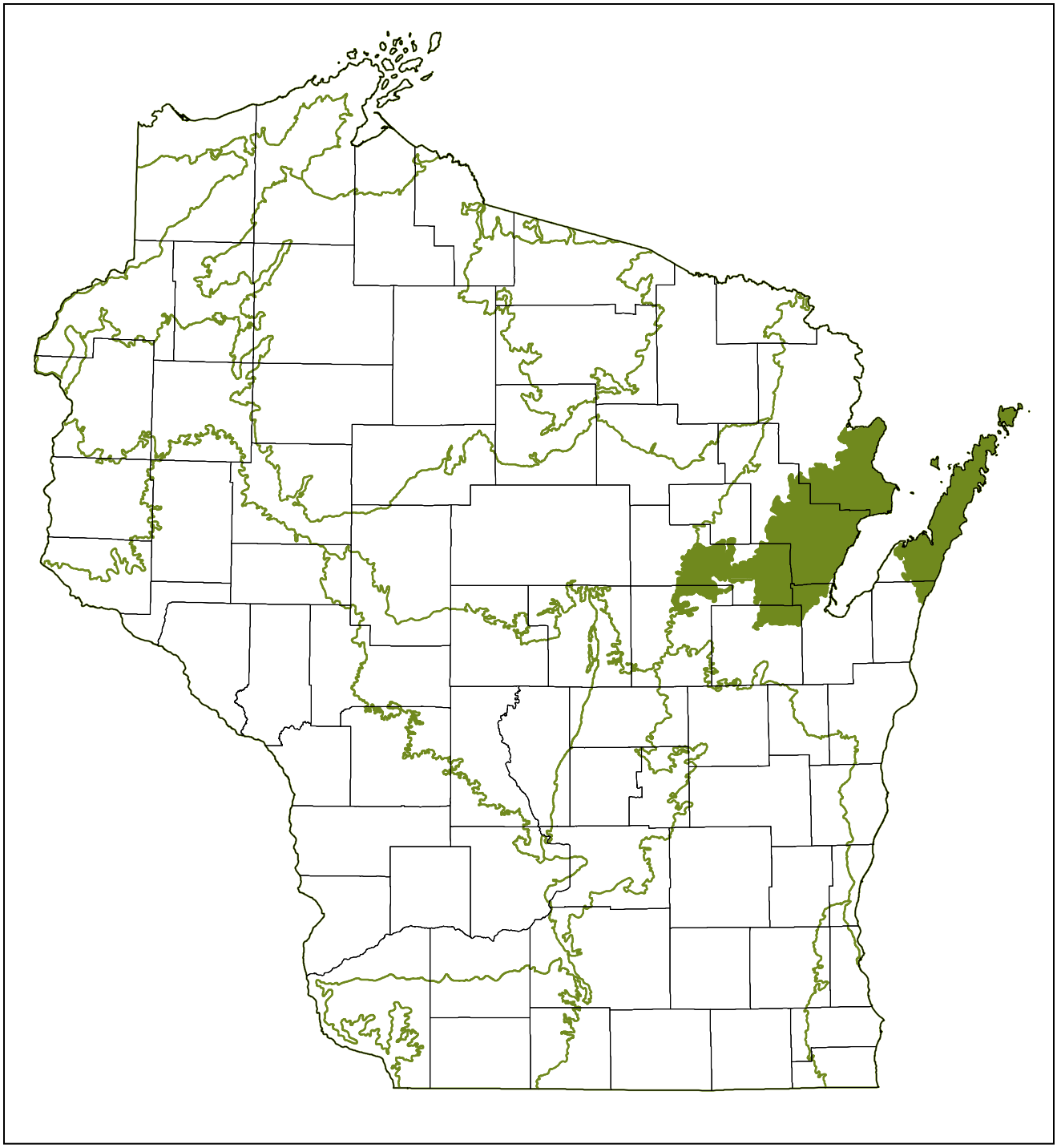
Large rookeries of colonial fish-eating birds occur on islands in Green Bay and Lake Michigan. Green Bay's low-lying west shore features extensive wetlands of marsh, sedge meadow, shrub swamp, and hardwood swamp. The remnant conifer-hardwood forests on the Door Peninsula's margins support diverse populations of breeding birds and are also heavily used by many migrants.

The northern Door Peninsula and associated Grand Traverse Islands present conservation opportunities offered nowhere else in Wisconsin. Unusual physiographic features such as ridge-and-swale complexes, embayment lakes, and freshwater estuaries are rich in rare natural communities, including beach, dune, bedrock shore, coastal fen, and boreal forest. These, in turn, support one of Wisconsin's greatest concentrations of rare species, some of them endemic to Great Lakes shoreline environments.

The dolomite Niagara Escarpment is a dominant geological feature of this landscape. On the west side of the Door Peninsula, the escarpment is exposed as cliffs, ledges, and talus slopes. Springs and seeps are present, and some of Wisconsin's oldest trees grow on the escarpment. To the east, along Lake Michigan, the same bedrock forms extensive horizontal rock "beaches." Scattered features of ecological importance include a stretch of the Menominee River at the northern edge of the landscape; a concentration of rich conifer swamps in the poorly drained terrain east and north of Lake Noquebay; extensive dry forests of aspen, oak, and pine on sandy soils in southern Oconto County; warmwater rivers and streams entering Green Bay from the west; and the northernmost stretch of the lower Wolf River.

Management opportunities vary greatly in different parts of the Northern Lake Michigan Coastal Ecological Landscape. The factors responsible for this include the past and present influence of Lake Michigan and Green Bay, the dolomite bedrock, the composition of the glacial till, and the highly variable landforms and their effects on land use. Because of this heterogeneity, Land Type Associations, which are fully described in the chapter on the Northern Lake Michigan Coastal Ecological Landscape, can be helpful in identifying, describing and framing management opportunities in greater detail at appropriate locations and at larger scales in this landscape.

Boreal Forest and Great Lakes Alkaline Rockshore, northern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.



Northern Lake Michigan Coastal Ecological Landscape

Northern Lake Michigan Coastal Ecological Landscape

Introduction

This is one of 23 chapters that make up the Wisconsin DNR's publication *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management.* This book was developed by the Wisconsin DNR's Ecosystem Management Planning Team (EMPT) and identifies the best areas of the state to manage for natural communities, key habitats, aquatic features, native plants, and native animals from an ecological perspective. It also identifies and prioritizes Wisconsin's most ecologically important resources from a global perspective. In addition, the book highlights socioeconomic activities that are compatible with sustaining important ecological features in each of Wisconsin's 16 ecological landscapes.

The book is divided into three parts. Part 1, "Introductory Material," includes seven introductory chapters describing the basic principles of ecosystem and landscape-scale management and how to use them in land and water management planning; statewide assessments of seven major natural community groups in the state; a comparison of the ecological and socioeconomic characteristics among the ecological landscapes; a discussion of the changes and trends in Wisconsin ecosystems over time; identification of major current and emerging issues; and identification of the most significant ecological opportunities and the best places to manage important natural resources in the state. Part 1 also contains a chapter describing the natural communities, aquatic features, and other selected habitats of Wisconsin. Part 2 of the book, "Ecological Landscape Analyses," of which this chapter is part, provides a detailed assessment of the ecological and socioeconomic conditions for each of the 16 individual ecological landscapes. These chapters identify important considerations when planning management actions in a given ecological landscape and suggest management opportunities that are compatible with the ecology of the ecological landscape. Part 3 of the book, "Supporting Materials," includes appendices, a glossary, literature cited, recommended readings, and acknowledgments that apply to the entire book.

This publication is meant as a tool for applying the principles of ecosystem management (see Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book). We hope it will help users better understand the ecology of the different regions of the state and help identify management that will sustain all of Wisconsin's species and natural communities while meeting the expectations, needs, and desires of our public and private partners. The book should provide valuable tools for planning at different scales, including master planning for DNR-managed lands, as well as assist in project selection and prioritization.

Many sources of data were used to assess the ecological and socioeconomic conditions within each ecological landscape. Appendix C, "Data Sources Used in the Book," (see Part 3 of the book, "Supporting Materials") describes the methodologies used as well as the relative strengths and limitations of each data source for our analyses. Information is summarized by ecological landscape except for socioeconomic data. Most economic and demographic data are available only on a political unit basis, generally with counties as the smallest unit, so socioeconomic information is presented using county aggregations that approximate ecological landscapes, unless specifically noted otherwise.

Rare, declining, or vulnerable species and natural community types are often highlighted in these chapters and are given particular attention when Wisconsin does or could contribute significantly to maintaining their regional or global abundance. These species are often associated with relatively intact natural communities and aquatic features, but they are sometimes associated with cultural features such as old fields, abandoned mines, or dredge spoil islands. Ecological landscapes where these species or community types are either most abundant or where they might be most successfully restored are noted. In some cases, specific sites or properties within an ecological landscape are also identified.

Although rare species are often discussed throughout the book, "keeping common species common" is also an important

Terms highlighted in green are found in the glossary in Part 3 of the book ("Supporting Materials"). Naming conventions are described in Part 1 in the Introduction to the book. Data used and limitation of the data can be found in Appendix C, "Data sources used in the Book," in Part 3.

consideration for land and water managers, especially when Wisconsin supports a large proportion of a species' regional or global population or if a species is socially important. Our hope is that the book will assist with the regional, statewide, and landscape-level management planning needed to ensure that most, if not all, native species, important habitats, and community types will be sustained over time.

Consideration of different scales is an important part of ecosystem management. The 16 ecological landscape chapters present management opportunities within a context of ecological functions, natural community types, specific habitats, important ecological processes, localized environmental settings, or even specific populations. We encourage managers and planners to include these along with broader landscape-scale considerations to help ensure that all natural community types, critical habitats, and aquatic features, as well as the fauna and flora that use and depend upon them, are sustained collectively across the state, region, and globe. (See Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book for more information.)

Locations are important to consider since it is not possible to manage for all species or community types within any given ecological landscape. Some ecological landscapes are better suited to manage for particular community types and groups of species than others or may afford management opportunities that cannot be effectively replicated elsewhere. This publication presents management opportunities for all 16 ecological landscapes that are, collectively, designed to sustain as many species and community types as possible within the state, with an emphasis on those especially well represented in Wisconsin.

This document provides useful information for making management and planning decisions from a landscape-scale and long-term perspective. In addition, it offers suggestions for choosing which resources might be especially appropriate to maintain, emphasize, or restore within each ecological landscape. The next step is to use this information to develop landscape-scale plans for areas of the state (e.g., ecological landscapes) using a statewide and regional perspective that can be implemented by field resource managers and others. These landscape-scale plans could be developed by Wisconsin DNR staff in cooperation with other agencies and nongovernmental organizations (NGOs) that share common management goals. Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book contains a section entitled "Property-level Approach to Ecosystem Management" that suggests how to apply this information to an individual property.

How to Use This Chapter

The organization of ecological landscape chapters is designed to allow readers quick access to specific topics. You will find some information repeated in more than one section, since our intent is for each section to stand alone, allowing the reader to quickly find information without having to read the chapter from cover to cover. The text is divided into the following major sections, each with numerous subsections:

- Environment and Ecology
- Management Opportunities for Important Ecological Features
- Socioeconomic Conditions

The "Environment and Ecology" and "Socioeconomic Conditions" sections describe the past and present resources found in an ecological landscape and how they have been used. The "Management Opportunities for Important Ecological Features" section emphasizes the ecological significance of features occurring in the ecological landscape from local, regional, and global perspectives as well as management opportunities, needs, and actions to ensure that these resources are enhanced or sustained. A statewide treatment of integrated ecological and socioeconomic opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book.

Summary sections provide quick access to important information for select topics. "Northern Lake Michigan Coastal Ecological Landscape at a Glance" provides important statistics about and characteristics of the ecological landscape as well as management opportunities and considerations for planning or managing resources. "General Description and Overview" gives a brief narrative summary of the resources in an ecological landscape. Detailed discussions for each of these topics follow in the text. Callout boxes provide quick access to important information for certain topics ("Significant Flora," "Significant Fauna," and "Management Opportunities").

Coordination with Other Land and Water Management Plans

Coordinating objectives from different plans and consolidating monetary and human resources from different programs, where appropriate and feasible, should provide the most efficient, informed, and effective management in each ecological landscape. Several land and water management plans dovetail well with *Ecological Landscapes of Wisconsin*, including the Wisconsin Wildlife Action Plan; the Fish, Wildlife, and Habitat Management Plan; the Wisconsin Bird Conservation Initiative's (WBCI) All-Bird Conservation Plan and Important Bird Areas program; and the *Wisconsin Land Legacy Report.* Each of these plans addresses natural resources and provides management objectives using ecological landscapes as a framework. Wisconsin DNR basin plans focus on the aquatic resources of water basins and watersheds but also include land management recommendations referencing ecological landscapes. Each of these plans was prepared for different reasons and has a unique focus, but they overlap in many areas. The ecological management opportunities provided in

this book are consistent with the objectives provided in many of these plans. A more thorough discussion of coordinating land and water management plans is provided in Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book.

General Description and Overview

The Northern Lake Michigan Coastal Ecological Landscape is located in the northeastern corner of Wisconsin. Bordered by Lake Michigan and Green Bay (Lake Michigan's largest bay), this ecological landscape encompasses areas as distinctive as the Door Peninsula, Grand Traverse Islands, and Niagara Escarpment; the vast marshes and meadows that border the nearly level but dynamic west shore of Green Bay; extensive areas of forested and shrub wetlands north and east of Lake Noquebay; and a short but ecologically significant stretch of the lower Wolf River corridor. Apart from some stretches of the immediate Lake Michigan and Green Bay coastal areas, much of this ecological landscape has been significantly altered and is now used primarily for agricultural purposes. The Northern Lake Michigan Coastal area is quite heterogeneous and from a conservation perspective could be regarded as several distinctive sub-landscapes with very different resource management opportunities: Door Peninsula-Grand Traverse Islands, west shore of Green Bay, Lake Noquebay-Menominee River, Wolf River corridor, and miscellaneous sites away from the influence of Lake Michigan and Green Bay or the other sub-landscapes mentioned. Some of the management opportunities (see "Management Opportunities for Important Ecological Features of the Northern Lake Michigan Coastal Ecological Landscape," below) and the Landtype Association map (see Appendix 15.K at the end of this chapter) offer descriptive information that may be helpful.

Major landforms consist of the Niagara Escarpment, a prominent dolomite outcropping bordering the east side of Green Bay on the western edge of the Door Peninsula; a lacustrine plain along the west side of Green Bay; and ground moraine (some of the ground moraine in southern Marinette County features drumlins). Low sand dunes and beach ridges are found along the Lake Michigan shoreline. Some of these support species endemic to the Great Lakes region, along with many other rare plants and animals. The influence of Lake Michigan moderates extreme temperatures. Soils are very diverse; in some areas, lacustrine sands are found overlying clays or bedrock within only a few feet of the surface. On the Door Peninsula, soils are typically stony loamy sands to loams. Poorly drained sands are common in the lake plain or in depressions between dunes and beach ridges. West of Green Bay, the ground moraine is composed mostly of moderately well-drained rocky sandy loams, interspersed with lacustrine sands and clays. Peats and mucks are also common.

Historical vegetation of the Northern Lake Michigan Coastal Ecological Landscape included extensive maple-basswood-beech and hemlock-hardwood forests, northern white cedar swamp, hardwood-conifer swamp, sedge meadows, and large areas of coastal marshes. Conifer-dominated upland forests that resemble "boreal forest" (Curtis 1959) were present in cool, moist climatic zones close to Lake Michigan; the forest canopies contain a significant amount of white spruce (*Picea glauca*) and balsam fir (*Abies balsamea*), along with other conifers. Cliffs, sinkholes, and dolomite ledges are associated with the Niagara Escarpment. Current vegetation consists of more than 60% nonforested land, most of which is in agricultural crops, with smaller amounts of grassland, wetland, shrubland, and urbanized areas. Specialty crops such as cherries and apples are commonly grown in Door Peninsula orchards. The largest change from historical vegetation has been the loss of forest cover, much of it replaced by farms or urban-industrial areas. Forested lands are dominated by maple-basswood, with smaller amounts of lowland hardwoods, aspen-birch, and lowland conifers. Areas of exposed dolomite bedrock shore occur on the east side of the northern Door Peninsula, providing habitat for many rare plants (including some of Arctic-alpine affinity). The Grand Traverse Islands occur in Green Bay and off the northern Door Peninsula and provide critical habitat for rare species, support rookeries of fish-eating birds, and are important staging, resting, and foraging areas for migratory birds.

This ecological landscape has an extensive shoreline along Green Bay on the west coast of Lake Michigan. Many small rivers and creeks drain the numerous linear wetlands on the west side of Green Bay that trend southwest to northeast. Large rivers that flow through the ecological landscape are the Menominee, Wolf, Oconto, and Peshtigo. There are few large inland lakes, but several of the larger embayment lakes—Europe (273 acres), Mackaysee (347 acres), and Clark (864 acres)—have good water quality coupled with low biological productivity. A few inland lakes, such as Bradley Lake, tend to have relatively high pollution levels due to agricultural nutrients combined with a lack of buffer zones and porous bedrock with thin soils. Other lakes or isolated portions of lakes (such as the southern part of Kangaroo Lake) are shallow and suffer from resuspension of sediments by carp, wind, or boating or have infestations of invasive plants, such as Eurasian water-milfoil (*Myriophyllum spicatum*), with low biological productivity. Only four lakes here are listed as water quality-impaired under the federal Clean Water Act, due to mercury contamination in fish (Corbisier 2000, Wisconsin DNR 2011).

The total land area for the Northern Lake Michigan Coastal Ecological Landscape is approximately 1.3 million acres, of which 37% is classified as timberland. About 3.5% of the ecological landscape is public land. Recreation is a major economic contributor to the Northern Lake Michigan Coastal counties, especially in Door County, with an above

average number of state parks and recreation areas. Agriculture is also a significant part of the economy of the Northern Lake Michigan Coastal counties but less than in some other ecological landscape county approximations. Farm acreage accounts for 32% of the land base in the counties, and total market value per acre of agricultural products is about average compared to other ecological landscape county approximations in the state. Specialty crops, such as apples and cherries, are grown on the Door Peninsula. The human population in the Northern Lake Michigan Coastal counties has been growing relatively rapidly since 1970, especially for adults over 65 retiring in Door County. The population density of the region (40 persons per square mile) is slightly less than half that of the state as a whole (105 persons per square mile) (USCB 2012). Among the 16 ecological landscapes, it has the second highest percentage of people over 65 years of age and the third highest median age. It has the third lowest percentage of minorities and the fourth lowest percentages of high school and college graduates. Economically, it is about average for the state, with slightly lower than average rates of unemployment and poverty. The percentage of farming jobs is second highest in the Northern Lake Michigan Coastal counties among ecological landscapes, whereas the proportion of government jobs is fourth lowest.

Environment and Ecology

Physical Environment

Size

The Northern Lake Michigan Coastal Ecological Landscape encompasses 2,004 square miles (1,282,877 acres), representing 3.6% of Wisconsin's land area.

Climate

Climate data were analyzed from six weather stations within the Northern Lake Michigan Coastal Ecological Landscape: Seymour, Bowler Ranger Station, Marinette, Oconto, Sturgeon Bay Experimental Farm, and Washington Island). This ecological landscape has a continental climate, with cold winters and warm summers. Overall, the climate is similar to other ecological landscapes in northern Wisconsin (Northwest Lowlands, Northwest Sands, Superior Coastal Plain, North Central Forest, Northern Highland, and Forest Transition). The northern ecological landscapes in Wisconsin generally tend to have shorter growing seasons, cooler summers, colder winters, and less precipitation than the ecological landscapes farther to the south. Ecological landscapes adjacent to the Great Lakes generally have warmer winters, cooler summers, and higher precipitation, especially snow, than inland areas. The climate in the Northern Lake Michigan Coastal Ecological Landscape is moderated by its proximity to Lake Michigan, leading to slightly warmer temperatures in the fall and early winter and slightly cooler temperatures during spring and early summer. This results in more growing degree days here than ecological landscapes farther inland in northern Wisconsin.

Temperatures are moderated by Lake Michigan. The one weather station inland from Lake Michigan that recorded temperatures and could calculate growing degree days (Bowler) had 23 fewer growing degree days than weather stations along the Lake Michigan shoreline (Marinette, Oconto, Sturgeon Bay, and Washington Island). The growing season averages 140 days (base 32°F) within this ecological landscape, ranging from 121 to 151 days. The mean growing season length is considerably longer in the Northern Lake Michigan Coastal Ecological Landscape (18 days) compared to the mean of other northern ecological landscapes. This is significant because the extended growing season and moderated temperatures allow the coastal areas of this ecological landscape to be a prime cherry and apple growing area.

The average annual temperature is 42.8°F, almost two degrees warmer compared to the mean of other northern ecological landscapes. Mean annual temperatures varied within the ecological landscape. Bowler Ranger Station, the one weather station inland from Lake Michigan that recorded temperatures, reported a mean annual temperature more than two degrees colder than weather stations along the Lake Michigan shoreline. The mean January minimum temperature is 0°F, more than one degree warmer than the mean January minimum temperature of other northern ecological landscapes. The mean August maximum temperature is 79°F, similar to the mean of other northern ecological landscapes. However, the mean temperature in January is almost six degrees colder inland from Lake Michigan than along the Lake Michigan shoreline. The mean August temperature is one and one-half degrees warmer inland than along the Lake Michigan shoreline (summer temperatures along the immediate Lake Michigan shoreline can be dramatically cooler than inland sites, or even sites located on the west side of Green Bay).

Annual precipitation averages 31.2 inches (28.5–32.4 inches), very similar to the mean annual precipitation of other northern ecological landscapes (31.6 inches). However, the annual precipitation here is the third lowest of all ecological landscape in the state. Annual precipitation did not differ greatly among inland weather stations (31.5 inches) and weather stations along the Lake Michigan shoreline (31.0 inches). Annual snowfall averages 46 inches, 12 inches less than other northern ecological landscapes (excluding the Superior Coastal Plain, which has greater snowfall due to lake effect snow). There is a large amount of variation in the amount of snowfall reported among weather stations within this ecological landscape. Weather stations inland from Lake Michigan that recorded snowfall (Bowler and Seymour) had a mean of 34.5 inches, while weather stations along the Lake Michigan shoreline (Marinette, Oconto, Washington Island, and Sturgeon Bay) had a mean of 46 inches, an 11.5-inch difference, indicating some lake effect snowfall (lake effect snows in areas immediately adjacent to Lake Michigan can be dramatic).

There is adequate rainfall and growing degree days to support agricultural row crops, small grains, and pastures, which are prevalent over much of this ecological landscape, except the far northwestern corner. The warmer temperatures along Lake Michigan in the fall and early winter, and slightly cooler temperatures during spring and early summer, influence the vegetation and ecology in this ecological landscape. Door County is especially affected by the influence of Lake Michigan and has a climate favorable to growing apples and cherries.

Bedrock Geology

The Northern Lake Michigan Coastal Ecological Landscape is underlain by a variety of sedimentary and igneous rocks of Silurian, Ordovician, Cambrian, and Proterozoic origin. Bedrock beneath the Door Peninsula is Silurian dolomite of the Niagara Escarpment. It is the most resistant of the Paleozoic rocks that occur in Wisconsin, so it often appears as ridges or cliffs where surrounding bedrock has been eroded (Schultz 2004). The north shore of Green Bay is underlain by the ***Sinnipee Group***, a dolomitic rock with strata of limestone and shale. Inland, bands of St. Peter Formation sandstone, Prairie du Chien Dolomite, and Cambrian sandstone lie roughly parallel to the shore. The far western part of the ecological landscape, in central Shawano County, is underlain by granite of the Wolf River Batholith. (Nomenclature used here is according to the Wisconsin Geological and Natural History Open-File Report "Bedrock Stratigraphic Units in Wisconsin" [WGNHS 2006]). See the map "Bedrock Geology of Wisconsin" in Appendix G, "Statewide Maps," (in Part 3 of the book, "Supporting Materials"). Glacial sediment in most of the area is 5–50 feet deep over bedrock, with the thickest deposits near the western boundary. In many places, till is thin enough that bedrock characteristics directly affect vegetation. Plant nutrients from limestone and dolomite have contributed to the development of unusual vegetative assemblages, which may include many ***calciphiles***. Fractures in the bedrock create ***microclimates*** that favor species requiring cool, moist conditions. Bedrock fractures also have a strong influence on drainage and water quality.

The Niagara Escarpment is a 650-mile long ***cuesta*** (bedrock ridge) of ***fossiliferous*** dolomitic limestone. It passes through northern Illinois south and west of Lake Michigan, runs along the western and northern shores of Lake Michigan in Wisconsin and Upper Michigan, then heads southeast under Lake Huron to Ontario and thence into New York, where it forms the dramatic Niagara Falls, and continues eastward to the area near Rochester, New York. Other areas of this deposit, in Iowa, northern Illinois, and Indiana, are deeply buried by glacial deposits. Dolomite of the Niagara Escarpment was formed from accumulated sediments of an ancient sea at around 415 to 430 million years ago, during the Silurian Period of the Paleozoic Era. The Niagara Escarpment is exposed as nearly continuous bluffs along the Green Bay shoreline of the Door Peninsula and some of its offshore islands and also outcrops as flat limestone pavement or low ledges at many locations to the east. Exposures of this bedrock are extensive at the eastern edge of the Door Peninsula along Lake Michigan, from Cave Point north to the Grand Traverse Islands and beyond. Bedrock slopes downward toward the east side of the peninsula into the Michigan basin, a down warping of Earth's crust that left the edges of the basin tilted up to form the cuesta. Niagara Escarpment outcrops are associated with many rare plants, land snails, and globally rare community types. The dolomite contains fossils of marine organisms, and fossil reefs have been found in this bedrock in ecological landscapes to the south, particularly in the Milwaukee-to-Racine area (Dott and Attig 2004).

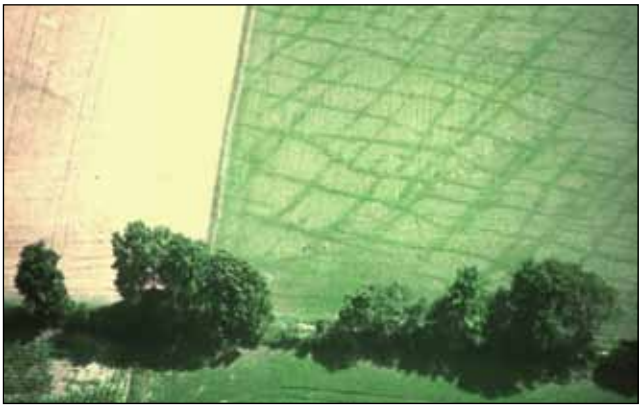
Dolomite is a sedimentary rock that originated as mud, with horizontal bedding-plane joints that developed between layers of sediment as they were deposited from oceans and vertical joints that formed when ancient seas retreated and the mud dried and cracked open in fissures. The dolomite is considered ***karstic*** on the Door Peninsula, with many fractures along both near-horizontal and vertical planes, and overlain by only a thin layer of till. Many fractures have enlarged to form sinkholes and other openings into the bedrock.

Caves have developed in places, although glacial scouring and deposition are thought to have removed many karstic features (Johnson and Stieglitz 1990). Tecumseh Cave (T. 29 N., R. 26 E., Sec 3, NE ¼ SW ¼) is noted for having over 3,000 meters of explored passages and is part of an extensive subsurface system that removes water from the land for a considerable distance east of the escarpment" (Stieglitz 1993). Additional karstic features, including several other caves, are mentioned by Johnson and Stieglitz (1990). The patterning of bedrock fractures is sometimes visible from the air and has been documented in photographs of alfalfa fields in dry conditions when the fractures, filled with silty or clayey glacial sediment, retain more moisture and appear greener. Areas that are shallow to bedrock have little soil to capture contaminants, and this characteristic together with fractured bedrock permits extremely rapid infiltration and movement of surface water into the aquifer, making the area highly susceptible to groundwater contamination (Schultz 2004, WGNHS 2009). Modeling and observations on aquifer behavior of city wells at Sturgeon Bay indicated that as few as eight or nine days were required for changes in water chemistry to appear after a high recharge event (Bradbury and Muldoon 1992, Bradbury et al. 2002).

The Door Peninsula has a number of bedrock valleys that cut across it in a northwest-to-southeast direction. These are believed to be preglacial features that were cut by ancient rivers and deepened by glacial activity. As the main ice sheet of the Green Bay lobe approached this area, it is likely that tongues of ice ahead of the main glacier filled and scoured these bedrock valleys, in a process similar to the creation of ***fjords*** and ***fjards*** (drowned glacial valleys). There are bedrock gaps at Sturgeon Bay, at Porte des Morts Passage between the Peninsula and Rock Island, between Ellison Bay

and Rowleys Bay and between Ephraim and Baileys Harbor. Several additional bedrock valleys that have been partially filled with sediment have been noted (Schneider 1993a). The filled valleys typically support swamps or contain small streams that run into Lake Michigan.

Silurian bedrock in the ecological landscape is confined to the northern Door Peninsula and consists of different formations. The oldest of these is the Mayville Formation, exposed in southern Door County but not within this ecological landscape. It is a dense rock of low permeability and forms the base of the dolomite aquifer. Its color varies but is generally medium gray in weathered outcrops. It is "***cherty***, coarse-grained, porous, massively-bedded, and fossiliferous" and averages about 100 feet thick (Bradbury and Muldoon 1992) although Johnson and Stieglitz (1990) give its thickness as 65 to 70 meters (213 to 230 feet). The next oldest Silurian rocks are the Byron and Hendricks formations of the Burnt Bluff Group, which form the largest cliffs. One of the most imposing dolomite cliffs of this formation is located on the shore of Eagle Harbor in Peninsula State Park, where it towers 150 feet above the water, and there are extensive dolomite exposures all along the Green Bay side of the peninsula north of Sturgeon Bay. The Byron Formation is white in outcrops, 65 to 100 feet thick, thin-bedded, very fine-grained, with little to no chert or fossils. The Hendricks Formation is tannish grey, 30 to 45 feet thick, thin- and thick-bedded, granular, and has no fossils (Bradbury and Muldoon 1992). The Manistique Formation is made up of the Schoolcraft and Cordell members, deposited on top of the Hendricks Formation. These layers are similar except for chert content; both are thin-bedded, light grey to buff-colored, granular, and contain many ***brachiopod*** and coral fossils. The lower-lying Schoolcraft Member is about 60 to 70 feet thick, and the Cordell Member is about 90 to 100 feet thick. The youngest Silurian deposit is the Engadine Formation, exposed intermittently on the east side of the peninsula. It is a dense, crystalline dolomite with fewer fossils than the Schoolcraft and Cordell formations and has variable bedding and texture. There is an exposure of the Engadine Formation along Lake Michigan at Cave Point in Whitefish Dunes State Park (Bradbury and Muldoon 1992).



Fractured bedrock underlying alfalfa field in Door County. Photo by Kenneth Bradbury, Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension.

Ordovician deposits lie beneath the Silurian rocks of Door County at a depth of about 300 feet below the land surface. The uppermost Ordovician rock is the Neda Formation, a discontinuous thin layer of fossiliferous ironstones, zero to seven feet thick. Next, the Maquoketa Shale forms a layer about 400 feet thick. It is a blue-gray shale, fine-to-medium bedded, and interbedded with dolomite near the top. Additional Ordovician deposits and Cambrian bedrock lie below it, and Precambrian rock is even deeper, typically at around 1,500 feet below the surface (Sherill 1978). The sequence of Ordovician and Cambrian bedrock that underlies the Maquoketa Shale is similar to that described in the Western Coulees and Ridges Ecological Landscape. Further descriptions may be found in Sherill (1978), and a generalized stratigraphic column of bedrock in Door County is given in Stieglitz (1993). Mai and Dott (1985) described the Ordovician sandstone of the St. Peter Formation in eastern and southern Wisconsin and also provided cross-sectional diagrams of bedrock that underlies it.

Ordovician dolomite with limestone and shale, in the Sinnipee Group, is the uppermost bedrock along the Green Bay shoreline in Marinette, Oconto, and Brown counties, overlying the St. Peter Formation sandstone and the Prairie du Chien Group dolomite with sandstone and shale. Younger rocks were worn away by erosion, so Silurian dolomites and Maquoketa shales do not occur in the ecological landscape outside Door County.

A narrow band of land is underlain by the St. Peter Sandstone, inland from and parallel to the area underlain by Sinnipee Group bedrock. The St. Peter Sandstone includes some limestone, shale, and conglomerate. The bedrock surface slopes eastward toward the Michigan basin, so progressively older rocks underlie the land toward the west side of the ecological landscape. Prairie du Chien dolomite is next in the sequence, and this rock includes some sandstone and shale. Finally, Cambrian sandstone with some dolomite and shale lies beneath the western edge of the ecological landscape in Marinette and Oconto counties and beneath the east-central part of Shawano County.

The Wolf River Batholith is an important geologic feature that underlies the westernmost part of the ecological landscape in central Shawano and northern Waupaca counties, where all Paleozoic rocks were removed by erosion. The batholith is made up of Precambrian rock produced by volcanic activity at about 1,485 million years ago (Greenberg et al. 1986). The volcanic event occurred over a wide area, including Missouri, Colorado, and Arizona, but its cause is unknown (Dott and Attig 2004). The batholith formed when granitic magma from deep in the Earth's crust intruded toward the surface and cooled and crystallized at the relatively shallow depth of one to two miles (LaBerge 1994). Wolf River rocks are dominantly granites and ***syenite***, with

smaller amounts of ***anorthosite*** and ***gabbro***; they underlie about 3,600 square miles in Wisconsin.

Landforms and Surficial Geology

The Northern Lake Michigan Coastal Ecological Landscape was almost completely covered by the Green Bay lobe during the late Wisconsin glaciation, which took place from approximately 26,000 till 10,000 years ago. There were undoubtedly a number of ice advances and retreats during that time, but later advances obscured and reworked earlier ones, so the surface features of the ecological landscape were formed by the last two advances of the Green Bay lobe at about 15,000 and 13,500 years ago. The sharp bedrock edge of the Niagara Escarpment separated the Green Bay lobe from the larger Lake Michigan lobe, and it eroded the less-resistant Ordovician bedrock to form Green Bay. Ice of the Green Bay lobe was centered over Green Bay and flowed out in a fan-like pattern, moving in a westerly and southwesterly direction over the main part of the ecological landscape but flowing toward the southeast across the Door Peninsula. A small area on the east side of the Door Peninsula was glaciated by the Lake Michigan lobe, which abutted the Green Bay lobe along the Door Peninsula. Glaciers built a land surface in this ecological landscape that is predominantly composed of undulating till plain, reworked and overlain in parts by deposits from glacial lakes. Till on the Door Peninsula is thin and draped over fractured dolomitic bedrock. Dunes and beach ridges were created by interglacial and postglacial lakes in the Michigan basin, and many of these landforms are evident near the Lake Michigan shoreline. The Wisconsin Geological and Natural History Survey is obtaining data to produce a detailed regional map, but meanwhile, information about this area comes from multiple sources and is not complete.

The oldest land surfaces are located in the westernmost part of the ecological landscape, in Waupaca and central Shawano counties. They were formed at around 14,200 to 15,600 years ago during the ***middle Athelstane phase***, in the next-to-last advance of the Green Bay lobe (Hooyer 2007). Deposits of this advance are the Kirby Lake Member of the Kewaunee Formation, a reddish-brown, dolomitic, silty clay loam that was mostly submerged and reworked by ***Glacial Lake Oshkosh*** (Hooyer and Mode 2007).

Glacial Lake Oshkosh existed during times when ice of the Green Bay lobe stood in the Fox River lowland between present-day Lake Winnebago and the city of Green Bay. Surface water draining northward through the lowland became ponded in front of the ice sheet until finding other outlets, either through the ancestral Wisconsin River valley or eastward to the Michigan basin. Five stages of Glacial Lake Oshkosh have been described (Hooyer 2007). The lake was at its highest level of elevation during the first stage at about 19,500 years ago, and additional significant stages occurred at around 15,000 and 13,400 years ago (Hooyer 2007). Glacial Lake Oshkosh varied in size depending on the location of the ice sheet; at its maximum it covered around 1.4 million acres, primarily within the Northeast Sands, Central Lake Michigan Coastal, and Southeast Glacial Plains ecological landscapes. Lacustrine silts and clays were deposited in the deeper portions of the glacial lakes, and sandy beach ridges, terraces, and dunes formed near the shorelines (Hooyer 2007, Hooyer and Mode 2007).

Most of the land surface in the ecological landscape is made up of the Middle Inlet Member of the Kewaunee Formation, the only exceptions being the Kirby Lake deposits in Shawano and Waupaca counties and landforms on the Door Peninsula (Clayton et al. 2006). The Middle Inlet Member was deposited by the final readvance of glacial ice at about 13,600 years ago, during the late Athelstane phase (Need 1985, Hooyer 2007). The till material is a dolomitic reddish-brown loam or sandy loam, some of which was also submerged in and reworked by Glacial Lake Oshkosh (McCartney 1983). A remnant end moraine of this deposit occurs in eastern Shawano County and another occurs in central Oconto County, but the rest of the Middle Inlet surfaces are till plains (WGNHS 1964).

Till plains of the Middle Inlet Member form the surface of most of Marinette, Oconto, Brown, and Outagamie counties as well as eastern Shawano County. They have an undulating subglacially molded topography and slope gently toward the east. Numerous drumlins formed of loamy calcareous till, some of them bedrock-cored, occur here. Drumlins are especially common in Marinette County. An esker approximately 30 miles long is located near the junction of Highways 141 and 64 north of Pound, where it has been quarried for gravel (Lorenz 2005). Much of the Middle Inlet Member is underlain by Ordovician dolomite and limestone within 50 feet of the surface. Many wetlands occur here due to impeded drainage caused by the fine-textured till.

Between the last two glacial readvances, from about 14,200 to 13,600 years ago, the climate warmed enough for a spruce-dominated forest to develop (McCartney and Mickelson 1982, Hooyer 2007). Wood and other forest litter from this spruce forest has been found buried under

Complex Great Lakes coastal landform, with alternating ridges and swales. Baileys Harbor, Door County. Photo by Wisconsin DNR staff.

glacial deposits of the Late Athelstane advance that began around 13,600 years ago. The extent of this forest, known as the Two Creeks Forest, was mostly within the Central Lake Michigan Coastal Ecological Landscape, but at least two documented sites are located in this ecological landscape in eastern Shawano County (McCartney and Mickelson 1982). See Chapter 8, "Central Lake Michigan Coastal Ecological Landscape," for more description of the Two Creeks Forest.

A portion of a sandy lake plain of ***Glacial Lake Nippissing*** lies at the northeast corner of the ecological landscape, along the Lake Michigan shoreline. It includes the towns of Marinette and Peshtigo and the outlets of the Menominee and Peshtigo rivers. Most of the lake plain lies to the northeast, in Upper Michigan, where it extends past the city of Escanaba and ends at the former Au Train-Whitefish drainage channel that carried glacial lake water from the Superior basin. The lake plain is nearly level, formed by Glacial Lake Nippissing of sandy lacustrine material overlying limestone and dolomite bedrock. The landscape is a series of old beach terraces, beach ridges, and dunes, and wetlands are common. Glacial Lake Nippissing deposits are generally found at elevations below 610 feet (Hooyer and Mode 2007).

The land surface of the northern Door Peninsula is predominately a thin till sheet that lies over Silurian dolomite bedrock, 3 to 10 feet below the surface (Schneider 1993b). Till surfaces originated from the Green Bay lobe, except for a small area along the Lake Michigan shoreline south of Sturgeon Bay, which was built by the Lake Michigan lobe. Unlike ice flow direction in the rest of the ecological landscape, the Green Bay lobe moved in a south to southeasterly direction across the Door Peninsula. The till has high pH values, like those of other Kewaunee Formation tills, because of the dolomite content. Most of the till surface is formed of the Liberty Grove Member of the Holy Hill Formation, although a small portion of this ecological landscape segment, south of Sturgeon Bay, is made up of the Glenmore and Two Rivers Members of the Kewaunee Formation (Clayton et al. 2006). Both the Glenmore and Two Rivers tills have characteristics similar to those of the Middle Inlet Member, being fine-textured, reddish-brown, and composed of reworked lake sediments (Need 1985, Hooyer 2007). The Two Rivers till, however, is distinguished by having been deposited by the Lake Michigan lobe of the glacier (Need 1985, Schneider 1993a, Schneider 1993b). The Liberty Grove Member is an older till than others in the ecological landscape, deposited from the advance of the Green Bay lobe that built many landforms of the Southeast Glacial Plains at around 16,000 to 17,000 years ago. The till is a yellowish-brown, calcareous loam that contains many dolomite pebbles and cobbles (Schneider 1993b). A cluster of drumlins formed of the Liberty Grove till, most of them only 10 to 20 feet high, can be viewed in Liberty Grove Township, west of Rowleys Bay near the tip of the Door Peninsula (Schneider 1993a). The drumlins are situated parallel to the direction of ice flow, oriented toward the south-southeast.

Later glacial readvances did not cover this part of the Door Peninsula, being unable to override the high cliffs of the cuesta, but ice likely did flow through and downcut the bedrock valleys across the peninsula. During glaciation, the Door Peninsula would have been a ***nunatak*** or a string of nunataks, exposed high ground protruding above the ice sheet (Schneider 1993b). Toward the tip of the Door Peninsula, more of the surface is of ***glaciolacustrine*** origin, including beach terrace and ridge deposits. Aeolian sand dunes also occur here, such as the dune field at Whitefish Dunes State Park (Schneider 1993a).

At various locations in the ecological landscape, ***proglacial*** stream sediments formed outwash plains, both pitted and unpitted, as well as outwash terraces and fans. Glacial lake plains, low sand dunes, and beach ridges are found where interglacial and postglacial lakes existed, and some of these features support Great Lakes endemics and other rare species. Postglacial erosion by streams, followed by redeposition of the sediment, led to the development of floodplains and terraces along rivers. The silty aeolian loess that was deposited over most of the state following glaciation is lacking here and is less than six inches thick in most of the ecological landscape (Hole 1976).

The Northern Lake Michigan Coastal Ecological Landscape includes three ecological units at the Subsection level, including the Green Bay Sandy Lake Plain Subsection (212Te), the West Green Bay Till Plain (212Tb), and the Door Peninsula Subsection (212Tf). For details on subsections, see the "Introduction" to this publication and the National Hierarchical Framework of Ecological Units map (Cleland et al. 1997) in Appendix G, "Statewide Maps," in Part 3 of the book ("Supporting Materials"). A map showing the ***Landtype Associations*** (Wisconsin Landtype Associations Project Team 2002) in this ecological landscape, along with the descriptions of the Landtype Associations, can be found in Appendix 15.K at the end of this chapter.

Northern Mesic Forest of American beech, American basswood, and sugar and red maple, on stabilized dunes along the eatern side of the Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

Interglacial and Postglacial Lakes in the Lake Michigan Basin

Features originating from late-glacial and postglacial lakes in the Lake Michigan basin occur here as well as in the other ecological landscapes along the lake. These lakes formed ahead of the glacier when the outlet from the Lake Michigan basin at the Straits of Mackinac was blocked by ice.

Former shorelines of the lakes are present at many locations in the ecological landscape, at elevations higher than the current Lake Michigan. The oldest and highest shorelines date from about 10,000 to 11,000 years ago, when Glacial Lake Algonquin occupied the basins of Lakes Michigan and Huron at water levels about 20 feet higher than the average current lake levels of 580 feet (Schneider 1993a, Dott and Attig 2004). The Nipissing Great Lakes formed at about 4,000 to 5,000 years ago, when ***isostatic uplift*** closed outlets to the north and water levels again rose to about 20 feet higher than present. Nipissing shorelines are often apparent in this ecological landscape, evidenced by beach ridges, dunes, and wave-cut terraces (Schneider 1993a, Dott and Attig 2004).

Isostatic uplift following glaciation has been greater in the northern part of the Great Lakes region. Glacial Lake Algonquin shorelines along the Door Peninsula are preserved because they were raised before the Nipissing Great Lakes existed, while shorelines along southern Lake Michigan were not raised, so Algonquin features there were obscured due to inundation by the Nipissing lakes (Dott and Attig 2004). Algonquin shorelines are at an elevation of 620 feet at Sturgeon Bay and 658 feet at Garrett Bay, indicating the differential rate of uplift (Schneider 1993a). The current rate of change in elevation contributes about 3.5 inches of elevation per century at Sturgeon Bay as compared with the southern shore of Lake Michigan (Larsen 1994). Algonquin shorelines are typically inconspicuous, marked by cobble beaches below wave-cut cliffs, or by low gravelly beach ridges (Schneider 1993a).

Nippissing shoreline features are common on the Lake Michigan side of the Door Peninsula. Kangaroo, Clark, and Europe lakes originated as bays along Lake Michigan but became separated by the buildup of Nipissing beach ridges and sand dunes along their mouths (Link et al. 1978, Schneider 1993a). A large dune field lies atop the Nipissing shoreline that separates Clark Lake from Lake Michigan at Whitefish Dunes State Park (Schneider 1993a).

Topography and Elevation

Elevation ranges from about 579 feet (mean water level for Lake Michigan from 1860 to 2011) to 1,158 feet in the Northern Lake Michigan Coastal Ecological Landscape. The lowest elevations are at the shores of Lake Michigan, but lake levels fluctuate by around 7.5 feet depending on climate (Thompson and Baedke 2000). The highest point is on a drumlin about a mile north of the town of Marion, in the far western portion of the ecological landscape in Shawano County. Topography is nearly level to gently undulating on lake plains, predominantly undulating on till plains, and undulating to hilly in end moraines. There are a few areas of steep topography, such as those associated with some stretches of the Peshtigo River or segments of the Niagara Escarpment.

Soils

Most upland soils in the Northern Lake Michigan Coastal Ecological Landscape formed in brown to reddish-brown, calcareous to neutral loam or sandy loam till on moraines and drumlins. The dominant soil is moderately well drained and loamy with a silt loam surface, moderate permeability, and moderate available water capacity. Drainage classes range from well drained to somewhat poorly drained, and soils generally have silt loam to loamy sand surface textures, moderate to moderately slow permeability, and moderate to high available water capacity. Many soils on the Door Peninsula and in the northern part of the ecological landscape are shallow to dolomitic limestone bedrock. Approximately a tenth of the area has upland soils formed in acid to calcareous sand on lake plains, former beach terraces, dunes, and localized outwash plains. These soils range from excessively drained to poorly drained and generally have loamy sand to fine sand surface textures, rapid to very rapid permeability, and low available water capacity. One of these areas is in the Sobieski Plains Landtype Association (212Tb27), a sandy lake plain with dunes, in Oconto and northern Brown counties. The Marinette Plains (212Te10) has sandy soils on beach terraces over bedrock with a high water table, so these soils are typically somewhat poorly drained to poorly drained. Wetlands occupy about 20% of the ecological landscape. Most lowland soils are very poorly drained non-acid muck, poorly drained loamy till, or poorly drained sandy lacustrine and outwash.

Hydrology

Basins

This heterogeneous ecological landscape contains four major water basins: Green Bay, Wolf River, Twin-Door-Kewaunee, and a short, northwesternmost stretch of the lower Fox River. Within these basins, there are 23 watersheds that lie entirely or partially within this ecological landscape (see Appendix 15.A at the end of this chapter). Most of these watersheds drain into the Green Bay portion of Lake Michigan, directly or via the Wolf and Fox rivers. Several small but biologically important streams flow from the Door Peninsula into the open waters of Lake Michigan north of Sturgeon Bay.

Lake Michigan

Lake Michigan and Green Bay are waterbodies of the highest ecological and socioeconomic importance. Lake Michigan is cold, clean, and deep. Climatically, physically, and hydrologically, much of the Northern Lake Michigan Coastal Ecological Landscape is characterized in large part by past and present impacts of the waters of Lake Michigan and Green Bay. Trending northeast-southwest, Green Bay splits this ecological landscape, dividing the larger western portion from the long and narrow Door Peninsula.

The east side of the Door Peninsula and many of the Grand Traverse Islands are bordered by the northern basin of Lake Michigan, which is deep (925 feet at its deepest point), cold, and relatively clean. The lake's influence on local climate is significant, producing cool, moist conditions during the growing season, which, along with other factors, enable the development and maintenance of a unique set of natural communities of unusual composition, limited geographic distribution, and high ecological value. Other shoreline features and phenomena, such as long- and short-term water level fluctuations, fogs, wave spray, storm wave impacts, ice push, and deposition and erosion of sediments have also strongly affected the ecology and land use patterns of this region. Species endemic to Great Lakes shoreline habitats occur here. Undeveloped shoreline habitats and the open waters of this ecological landscape are highly significant to fish and migratory birds.

Water levels rise and fall, but Lake Michigan does not experience the more pronounced short-term fluctuations that occur in Green Bay during major ***seiche events*** (see below) or storms (Wisconsin DNR 2001a, Epstein et al. 2002a). The extent of unusual and ecologically valuable shoreline habitats, such as sand, cobble, and bedrock beaches, can vary dramatically with these long-term changes in water levels.

The lake's fishery (e.g., lake trout [*Salvelinus namaycush*], lake whitefish [*Coregonus clupeaformis*], yellow perch [*Perca flavescens*], and ciscoes, especially the cisco known as "lake herring" [*Coregonus artedi*] and bloater chub [*Coregonus hoyi*]) was formerly of great commercial significance, but overexploitation of the resource, habitat degradation, and the negative impacts of invasive exotic species such as the sea lamprey (*Petromyzon marinus*) led to the disappearance or drastic reduction of some species, greatly diminishing the commercial fishery's economic importance. The lake whitefish remains locally abundant and is featured in the still popular "fish boils" in Door County. The commercial fishery has been replaced, to a degree, by a sport fishery that is based on the introduced exotic salmonids that now occupy the top predator positions in Lake Michigan.

Green Bay is relatively shallow, warm, and productive. Changes in Lake Michigan water levels can have a significant effect on coastal marshes, vegetation, and navigation, especially in Green Bay. Short-term (hours to days) water level changes are sometimes dramatic due to seiches. Seiches are caused by a combination of rapid changes in barometric pressure, currents, winds, and the physical attributes and orientation of large waterbodies. These are most pronounced when strong winds "pile up" water on the downwind side of the lake. When the winds subside, the water "sloshes" back to the original shore causing water levels to rise and fall. Because of the depth of the water and morphology of the basin, seiches can be significant in Green Bay. The rapidly changing water levels caused by seiches can strongly impact coastal marsh vegetation.

Longer-term water level changes, due to drought or extended wet periods, also impact coastal marsh vegetation, especially in Green Bay. During periods of low water, lands occupied by coastal marshes and sedge meadows may dry out, allowing succession to communities dominated by woody plants, such as shrub-carr or hardwood swamp. During periods of high water, coastal wetlands are flooded and may diminish in size because of greater depth, turbidity, and wave or ice erosion. Global climate change could have major influences on the composition, structure, and function of the coastal wetlands and on the Great Lakes themselves.

Many wetlands along the west shore of Green Bay were altered or lost due to conversion to agricultural use, dredge spoil disposal, stream channelization, road construction, and residential development (Bosley 1976, 1978; Harris 1993). Green Bay itself has undergone significant changes to its aquatic communities. Among the most important factors have been industrial and agricultural contamination (see the "Water Quality" section below) and invasion by a host of nonnative species. Development pressures in the Green Bay basin have created concerns over the viability of remaining wetlands and marshes, especially along the west shore. Residential and recreational developments (often with associated hydrological modifications such as ditching, diking, channelization, pond construction, and groundwater withdrawals), agricultural runoff (which occurs from lands west of Green Bay and on the western part of the Door Peninsula), and infrastructure construction such as roads, power lines, culverts, and ditches can disrupt hydrology, serve as a source of pollutants, facilitate the spread of invasive species, and act as physical barriers inhibiting or preventing the movements of some species. Various public and private conservation programs are engaged in habitat protection and restoration of lost function.

Despite Green Bay's past history of significant pollution, it supports significant populations of smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), northern pike (*Esox lucius*), yellow perch, and many nongame fish. Shallow bays containing beds of emergent and submergent marsh vegetation provide critical spawning and fry-rearing habitat for the previously mentioned game fish and many other species. The cobble and boulder bottom along much of the east shore of the bay is ideal habitat for smallmouth bass, which feed heavily on crayfish, mayflies, dragonfly larvae, and other organisms inhabiting these rocky bays and offshore shoals. Though much of Green Bay is shallow, the northernmost part of the bay reaches a depth of at least 131 feet (Wisconsin DNR 2001a).

Inland Lakes

Inland lakes are uncommon in this ecological landscape because of the predominant landforms and geology. According to the Wisconsin DNR's 24K Hydrography Geodatabase, there are only 71 named inland lakes here, totaling 5,839 acres (Wisconsin DNR 2012a). There are 1,711 small

Small pond bordered by open and forested peatlands. Clark Lake, a former Lake Michigan embayment, is in the background. Lake Michigan is in the foreground. Door County north of Sturgeon Bay. Photo by Eric Epstein, Wisconsin DNR.

unnamed lakes ("ponds"), which collectively cover only 1,172 acres. Many of the inland lakes are in the western part of this ecological landscape, in portions of Shawano, Oconto and Marinette counties. Several large "***embayment lakes***" (Clark, Europe, and Kangaroo lakes) on the east side of the Door Peninsula are now from Lake Michigan by ***baymouth bars*** or ***dune fields***. All of these embayment lakes contain or are bordered by significant wetland communities, which include marshes, sedge meadows, fens, and conifer swamps. Rare plant and animal species are known to inhabit these wetlands and some of the adjoining upland forests.

Impoundments

Several of the major rivers and many small streams here have been dammed since Euro-American settlement. A total of 71 dams have been constructed in this ecological landscape. Over the past 30 years, 11 of these have been abandoned and removed (as of 2009), leaving 60 dams on rivers and streams. The impoundments behind the dams cover 7,177 acres. This has caused the loss or alteration of in-stream habitat, loss of habitat connectivity, created barriers to the movements of aquatic organisms, increased water temperature, and led to local water quality impairment.

Lake Noquebay is a 2,409-acre impoundment of Middle Inlet Creek, a tributary to the Peshtigo River, amid a setting dominated by wetlands. Lake Noquebay is the only listed wild rice (*Zizania* spp.) lake in this ecological landscape (Wisconsin DNR and GLIFC data). It also supports a population of a rare dragonfly, the slaty skimmer (*Libellula incesta*).

Machickanee Flowage is a 463-acre impoundment created by the Stiles Dam on the Oconto River. This impoundment accumulated an enormous volume of ammonia and heavy metal pollutants from a pulp mill at Oconto Falls and suffered severe water quality and habitat degradation problems for decades until the mill was shut down in 1978. A restoration plan implemented in the early 1980s has resulted in significant improvements to water quality and aquatic habitat, although sediment nutrients still contribute to an overabundance of aquatic vegetation (Rost 1989). The reservoir is currently a popular boating and angling destination. The Oconto Falls Flowage is a 167-acre hydroelectric impoundment that is operated as a ***run-of-the-river system***, meaning that water levels in the reservoir don't fluctuate much.

Rivers and Streams

There are 865 miles of perennial streams flowing through the Northern Lake Michigan Coastal Ecological Landscape (Wisconsin DNR 2012a). The larger western portion of this ecological landscape is drained by a number of streams that are significant for their recreational as well as their ecological values. These include the Menominee, Peshtigo, and Oconto rivers as well as a few miles of the lower Wolf River in Shawano County. Many rivers and streams here, large and small, are used seasonally by both native warmwater fish and by introduced populations of salmonids that spawn—but do not successfully reproduce (due to elevated water temperatures and sediment loads that smother salmon eggs)—on runs from Lake Michigan. In addition to the larger streams noted above, these streams include the Ahnapee and Little rivers and Hibbard, Ephraim, and Stony creeks.

The porous nature of the karst topography of the Door Peninsula, as well as other factors such as increased runoff due to the replacement of forest cover with agricultural fields and residential areas, limit the number of perennial streams in Door County (Wisconsin DNR 2001a). Though small, several of these streams are important because they support aquatic species that are rare in or absent from other parts of the state and because they feed and flow through important wetlands.

Streams originating in heavily forested areas in adjacent ecological landscapes, such as the Oconto and Peshtigo, feature good water quality in their upper reaches and a broad range of aquatic habitats that support many aquatic species. The falls and rapids in the upstream reaches were created by geologic faults, resulting in varied bottom substrates and gradients. Systematic sampling has been inadequate to assess the conservation values of some of the smaller streams in this ecological landscape, especially for aquatic organisms other than fish (B. Smith, Wisconsin DNR, personal communication).

There are very few rivers and streams in this ecological landscape designated as ***Conservation Opportunity Areas*** (COAs) by the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b). Logan Creek, Hibbard Creek, and the Mink River, all in Door County, are part of the Great Lakes Shoreline Communities COA. These streams and their associated wetland communities are considered globally important, according to evaluation criteria used by the Wisconsin Wildlife Action Plan. The other river COA in this ecological landscape includes roughly four miles of the Wolf River below Shawano, a stream reach rich in fish and aquatic invertebrates.

There are relatively few springs or spring-fed headwaters streams here and, consequently, few high-quality coldwater streams (see "Springs" section below). Some streams that flow into Lake Michigan have been designated as trout streams because they host runs of nonnative ***anadromous fish*** that live primarily in Lake Michigan. The Embarrass River is an Exceptional Resource Water (ERW) with some trout reproduction in its upstream reaches within this ecological landscape. The North Branch of the Embarrass has excellent trout habitat and trout reproduction within the Northern Lake Michigan Coastal Ecological Landscape. Other notable coldwater streams include the North Branch and South Branch of Beaver Creek, the upper West Branch of the Shioc River, Mill Creek, and a short reach of the Red River in Shawano County.

Coolwater streams in this ecological landscape are often the downstream reaches of coldwater streams. The lower North Branch of the Embarrass River is a coolwater stream, formed by coldwater tributaries. Below the Pella Dam, this stream features a floodplain less extensive than but otherwise similar to the lower reaches of the Wolf River, and it is rich in aquatic invertebrate species and other fauna.

The South Branch of the Embarrass River, below its last downstream dam at Tigerton, supports a significant population of the Wisconsin and U.S. Endangered (federally listed in 2012) snuffbox mussel (*Epioblasma triquetra*) as well as other rare mussels. This stream supports at least 20 species of fish including a population of lake sturgeon (*Acipenser fulvescens*) that spawns in the Embarrass River below the Pella Dam (J. Lyons, Wisconsin DNR, personal communication). Other coolwater streams support a fish assemblage that transitions from low-productivity trout dominance to characteristic warmwater sport fish.

The upper parts of the watersheds of the larger warmwater rivers in this ecological landscape are generally heavily forested, with most of the contiguous forest occurring in ecological landscapes to the north and west. Closer to Green Bay of Lake Michigan, land use changes and rivers become strongly influenced by agricultural, industrial, and residential uses. Siltation, loss of floodplain wetlands and upland forest, soil erosion from intensive row crop production, industrial pollutants, urban runoff, and many hydrological alterations have combined to lower water quality and diminish habitat values.

The lower Wolf River flows through this ecological landscape for about 12 miles and is very different from the upper reaches, which are rocky, swift, and shallow in some stretches and flow through a region that is almost entirely forested. In the Northern Lake Michigan Coastal Ecological Landscape, just below a geologic fault transition, the Wolf River becomes a low-gradient, deeper stream with a prominent floodplain that supports extensive bottomland hardwood forest. Land cover outside of the river's floodplain is dominated by agriculture (row crops, hay, pasture). This portion of the Wolf River and its floodplain support important populations of many aquatic Species of Greatest Conservation Need, especially mussels and dragonflies as well as rare birds and mammals (see the "Fauna" section below).

The Peshtigo River originates in the North Central Forest Ecological Landscape, flows southeastward through the Northeast Sands Ecological Landscape, and then into the Northern Lake Michigan Coastal Ecological Landscape before reaching Green Bay. Water quality in the upper river is somewhat protected by the extensive forest cover within the watershed. However, in the Northern Lake Michigan Coastal Ecological Landscape, the Peshtigo River undergoes a transformation from a higher gradient stream to a lower gradient, slower and more meandering stream. Much of the forest has been cleared, and agricultural uses become increasingly important, leading to elevated levels of suspended sediments and nutrients. Near Porterfield, an impounded stretch of the Peshtigo passes over a fall line of dolomite over basalt, which divides the river into two distinct habitat types. From its mouth to the first dam, the Peshtigo River is very rich in aquatic invertebrates and fish species. Several rare fish are present in this segment of the lower Peshtigo River, including lake sturgeon. Floodplain forest is fairly extensive along this stretch, which is close to the northern edge of range for the type.

The Menominee River basin consists mostly of sand and gravel outwash that is underlain by dolomite (USEPA 2008). Forming the northwestern border of the ecological landscape, the Menominee River features clean water and diverse bottom materials of boulders, cobbles, sand, and silt. Though much of the land through which the Menominee passes has been cleared of native vegetation, the stream banks themselves are mostly intact. It hosts a moderate diversity of listed invertebrate species but does not support large populations of any of them. The same holds true for fish diversity, which is suppressed by the habitat fragmentation impacts of dams at Marinette, Menominee, and Grand Rapids. The limited population of lake sturgeon noted above uses the last mile of the

Extensive sedge meadow and marsh habitat at the Peshtigo River delta, Marinette County. Photo by Eric Epstein, Wisconsin DNR.

river and has access to Green Bay but has no access to prime upstream spawning and rearing sites. Fish biologists estimate this population at 1,000 adults. Some of the free-flowing sections support large populations of smallmouth bass.

This river corridor is largely undeveloped, being managed for a variety of quiet recreation uses (including river running and sportfish angling), active forest management, and limited areas of old-growth forest. Also, plans have been developed to construct fish lifts to pass sturgeon to the river upstream of the two lower dams, resulting in access to more than 20 miles of suitable spawning and rearing habitat (GLRI 2010).

Based on water quality and substrate characteristics alone, the Menominee River should hold more sensitive species, a greater diversity of species overall, and larger populations of some species. However, it is likely that the impacts of ten upstream dams that are managed as hydropower peaking plants create suboptimal habitat conditions for the many mussel and other species that are not adapted to the variations in stream flow or water temperature created by these dams. Biologists also suspect that, historically, the operation of mines on tributaries of the Menominee River in Michigan may have negatively impacted water quality by creating acidic conditions that eliminated populations of species that are intolerant of low pH environments (B. Smith, Wisconsin DNR, personal communication).

For 80 years, the Oconto River was the most polluted river in Wisconsin due to heavy discharges of pulp mill effluent. Twenty miles downstream from the discharge site in Oconto Falls, dissolved oxygen levels were measured at 0.0 ppm. Fumes from the river not only stained the paint on homes but also discolored porcelain bathroom and kitchen fixtures and dinner-wear (Rost 1989). A river restoration plan succeeded in restoring habitat values and aquatic invertebrate communities and allowed the reintroduction and recolonization of some fish species. However, even after 30 years of recovery, biotic diversity remains impaired due to greatly elevated sediment nutrients that promote excessive aquatic macrophytes.

The Little Wolf River flows through the far western lobe of this ecological landscape and joins the Wolf River in southeastern Waupaca County. The lower reaches of the Embarrass River flow through Outagamie County and join the Wolf River near New London. The Red River in Shawano County, downstream of Gresham to the Wolf River, is an ERW stream. The Little Wolf, Embarrass, and Red rivers all have good water quality and habitat characteristics that support warmwater sport fish populations and good invertebrate diversity (B. Smith, Wisconsin DNR, personal communication). Of these, the Red River has not been surveyed as well as the others. Based on its habitat characteristics and its connection to the biologically rich Wolf River, the Red River has the potential of supporting a diverse native aquatic fauna, and merits further biological survey.

A number of warmwater streams flowing through heavily agricultural areas lack the thermal regulation created by a forested watershed. Water temperatures may have been lower or had more stability prior to large-scale deforestation and intensive agricultural use within the watersheds.

Springs

There are only 18 mapped springs in this ecological landscape (Macholl 2007). This is reflected in the fact that there are very few high quality coldwater trout streams here. The coldwater flow from springs is critical to maintaining the low temperature and high dissolved oxygen content vital to the health of the coldwater stream community. Spring flow can help to support populations of coldwater organisms, including native brook trout (*Salvelinus fontinalis*), that cannot tolerate warmwater temperatures and/or low oxygen levels. Springs and seeps also feed alkaline wetlands, providing sources of cold, clean, and on the Door Peninsula and perhaps elsewhere, calcium-enriched, water. This is critical for some of the plants (e.g., the northern "fen" species) associated with the Niagara Escarpment and other calcareous bedrock features.

Wetlands

Wetlands are relatively common in this ecological landscape (261,662 acres, or 20.4% of the Northern Lake Michigan Coastal Ecological Landscape), with concentrations occurring along the west shore of Green Bay, in estuaries and embayments near Lake Michigan, and in the area north and east of Lake Noquebay. Forested wetlands are most extensive (213,900 acres), followed by shrub/scrub wetlands (31,100 acres), and herb-dominated emergent/wet meadow complexes (16,280 acres) (WWI 2010). Important floodplain forests are associated with several of the larger rivers and streams, such as the Wolf, Menominee, and Peshtigo, but these are less extensive than the lowland hardwood forests farther south and west.

Vast wetlands historically covered the west shore of Green Bay, and these were highly significant to spawning northern pike, walleye, and other fish species and provided habitat for

Rich fen dominated by wire-leaved sedges, bordered by a conifer swamp and sandy ridges forested with eastern hemlock, red maple, and American beech. Northeastern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

Mud Lake, marsh, sedge meadow, cedar swamp. Northeastern Door Peninsula, north of Baileys Harbor. Photo by Mike Mossman.

Complex mosaic of coastal wetland communities, part of a large protection project. Northeastern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

large numbers of migratory and breeding waterfowl and other birds, herptiles, and invertebrates. Before Euro-American settlement, many more wetlands here were hydrologically connected to Green Bay. As the area was settled by Euro-Americans, residential developments were located as close to the waters of Green Bay as possible during dry periods with low water levels in the bay. When water levels rose again, these developed areas were "protected" from the intrusion of the bay water by dikes and ditches. This resulted in the outright destruction of many wetlands, and many more wetland acres were hydrologically isolated from Green Bay. The area of functional wetlands shrunk drastically during high water periods (which occur cyclically) as the remaining wetlands were almost totally inundated.

Water level fluctuations in Green Bay are cyclical and occur on a daily, seasonal, and decadal basis. Short-term water level fluctuations caused by seiches (see above) considerably alter the extent of wetlands in lower Green Bay, particularly along the west shore. This phenomenon is described by Harris et al. (1977) and further elaborated upon by Bosley (1978), Harris et al. (1981), and Fewless (1986).

Fluctuations of water levels in the Fox River allow nutrient and silt-laden water to inundate the marsh. Pollution and siltation has degraded this wetland complex that was historically one of the finest and largest wetlands in the Midwest (see the "Fauna" section below).

The more prominent vegetation changes in and around Green Bay occur at intervals of 10–20 years. In the past, marsh vegetation in at least some parts of the bay was reduced by as much as 90% during periods of high water (Bosley 1978, Frieswyk and Zedler 2007). As an example, water levels reached a historic high in 1986 and then dropped by 1.25 m to reach a historic low from 1997 to 2001. During the historic low, invasive common reed (*Phragmites australis*), narrow-leaved cat-tail (*Typha angustifolia*), and hybrid cattail (*Typha* x *glauca*), becoming the overwhelmingly dominant wetland plants in the west shore marshes, especially in lower Green Bay (see the "Invasive species" section below).

The Door Peninsula is the somewhat isolated eastern third of this ecological landscape. Important wetlands are associated with several streams that drain the peninsula, the groundwater-fed basins of the major coastal embayments, the coastal waters of Green Bay and Lake Michigan, and the lowlands occupying the ridge-and-swale landforms along Lake Michigan. At least some of these wetlands are fed by alkaline groundwater from the underlying karst formations. The recharge areas for these groundwater flows can extend for a considerable distance from the wetlands they refresh. Surface flows in these wetlands are dependent on topography, local precipitation patterns, soils, land use, and land cover. Based on the interaction of these factors and their impacts on water table fluctuations, surface discharge may periodically disappear for periods of up to several months.

Water Quality

Outstanding Resource Waters (ORW) and ***Exceptional Resource Waters (ERW)*** are surface waters that have good water quality, support valuable fisheries and wildlife habitat, provide outstanding recreational opportunities, and are not significantly impacted by human activities. Waters with ORW or ERW status warrant additional protection from the effects of pollution or other forms of habitat degradation. Both designations have regulatory restrictions, with ORWs being the most restricted. These designations are intended to meet federal Clean Water Act obligations and prevent loss of water quality or degradation of aquatic habitats. They are also used to guide land use changes and human activities near these waters.

In this ecological landscape, only Mink River Lake meets the water quality and habitat criteria to qualify as an ORW lake, and there are no ERW lakes. There are 44 ORW or ERW streams here, and only four of these are in Door County, with the remaining 40 located in Marinette, Oconto, and Shawano counties west of Green Bay. ORW/ERW streams include the Red, Mink, West Branch Shioc, and Embarrass rivers along with Willow, Mill, Logan, Spencer, West Branch Beaver, and Mill creeks. A complete list of ORWs and ERWs

in this ecological landscape can be found on the Wisconsin DNR's website (Wisconsin DNR 2010a).

Streams with mostly forested watersheds tend to have good water quality. The Menomonee River, for example, emerges from a heavily forested landscape and carries relatively few pollutants into more developed areas closer to Lake Michigan. Under moderate and high flow conditions these larger rivers can absorb a limited amount of pollutant inputs from lower-quality tributaries in this ecological landscape without suffering significant adverse water quality impacts. The Total Maximum Daily Load (TMDL) process underway across the state will quantify what this limit should be. Smaller streams may be more affected by local land use. Some suffer from excess sediment and nutrient runoff from unbuffered or poorly managed row-crop fields. Sewage treatment plants in need of upgrading can also cause discharge problems.

Waters designated as 303(d) impaired under the Clean Water Act by the U.S. Environmental Protection Agency (EPA) exhibit various water quality problems including polychlorinated biphenols (PCBs) in fish, sediments contaminated with industrial metals, mercury from atmospheric deposition, bacteria from farm and urban runoff, and habitat degradation. Since the 303(d) designation is narrowly based on the criteria above, a waterbody could be listed as a 303(d) water as well as a ORW or ERW. These designations are not mutually exclusive. A plan is required by the EPA on how 303(d) designated waters will be improved by the Wisconsin DNR. This designation is used as the basis for obtaining federal funding, planning aquatic management work, and meeting federal water quality regulations.

Numerous lakes and streams in this ecological landscape are designated as 303(d) impaired waters. These waters include reaches of the Embarrass River, Ahnapee River, Clark Lake, East Alaska Lake, Green Bay (south of Marinette) and its tributaries, Menominee River, lower Peshtigo River, lower Oconto River, MacKaysee Lake, Stony Creek, Crescent Bay Beach (Lake Michigan at Algoma), Sunset Beach at Sturgeon Bay, and Lake Michigan's open waters. Fish consumption advisories, low oxygen, and excessive sedimentation are the major water use impairments found in these waters. The complete list of 303(d) list of impaired waters and criteria can be viewed at the Wisconsin DNR impaired waters web page (Wisconsin DNR 2013c). The impact of this water pollution on human health, aesthetics, and biodiversity was one of the prime drivers behind state and federal water pollution control laws and programs. Since the 1960s, these programs have significantly improved water quality in Green Bay (Wisconsin DNR 1993a).

From the latter part of the 19th century through the first half of the 20th century, Green Bay was impacted by industrial (e.g., paper mills) and municipal wastewater discharges and other pollutant sources, much of it entering via the Fox River at the City of Green Bay (in the Central Lake Michigan Coastal Ecological Landscape). The impacts of the excess nutrients in these wastes have been greatly reduced since implementation of the Clean Water Act in 1972. However, industrial contaminants remaining in the sediments here include PCBs, dioxins/furans, the pesticide DDT and its metabolites (DDD and DDE), the pesticide dieldrin, and arsenic, lead, and mercury.

Industrial contaminants also impact the Great Lakes; in 1972 an agreement was signed between the U.S. and Canadian governments that set water quality objectives for the Great Lakes basin. The agreement, as amended in 1987, defined Great Lakes ***Areas of Concern*** as areas with severe environmental degradation that "has caused or is likely to cause impairment of beneficial use" or has impacted an "area's ability to support aquatic life" (IJC 1987). The agreement directs the two governments to establish a ***Remedial Action Plan*** for restoring and protecting each Area of Concern. The Water Quality Agreement was most recently amended in 2012 (IJC 2012). The ***International Joint Commission*** (IJC), an independent organization established in 1909 by the Boundary Waters Treaty between the U.S. and Canada, is directed by the Water Quality Agreement to report biennially to the U.S. and Canadian governments as well as state and provincial governments regarding progress in achieving the agreement's objectives. The International Joint Commission is responsible for collecting and analyzing water quality data and advising the two governments about water quality in the Great Lakes. Initially, 43 Areas of Concern were identified within the Great Lakes basin: 26 entirely within U.S. waters, 12 within Canadian waters, and five shared by both countries (USEPA 2013). Since then, two AOCs within the U.S. have been delisted, and three Canadian AOCs have been delisted.

Within the Northern Lake Michigan Coastal Ecological Landscape, the Menominee River has been listed as an Area of Concern (AOC), as identified by the Great Lakes Water Quality Agreement between the U.S. and Canadian governments. The Menominee River forms the boundary between the northeast corner of Wisconsin and the southern tip of the Upper Peninsula of Michigan. The river's headwaters originate in both states. The main stem of the river flows between the cities of Menominee, Michigan, and Marinette, Wisconsin, before emptying into Green Bay.

The Menominee River AOC includes the lower three miles (4.8 km) of the river from the Upper Scott Paper Company (Wisconsin) Dam to the river's mouth and approximately 3.1 miles (5 km) north and south of the mouth along the adjacent shoreline of Green Bay. The AOC also includes the cities of Marinette, Wisconsin, and Menominee, Michigan, as well as the adjacent nearshore area of Green Bay, Wisconsin, extending three miles north to John Henes Park and south of the river mouth to the point of land known as Seagull Bar. The AOC also includes Green Island. Land use in the AOC is primarily industrial and residential. A chemical company, two paper mills, two municipal wastewater treatment plants, a ship building company, and a foundry are located along the river. The AOC watershed is shared between Michigan and Wisconsin.

Another significant source of contamination within the Menominee River AOC resulted from a manufactured gas plant in Marinette that produced gas from coal and oil from 1910 to 1960 (USEPA 2013). The resulting oils and coal tars contaminated soil and groundwater. This site and the Ansul Inc. site are both U.S. EPA Superfund sites and are currently undergoing a coordinated cleanup.

Paint sludge and coal tar were also identified by the EPA as pollutants of concern within the Menominee River AOC (USEPA 2013). On the Michigan side, remediation of the paint sludge site was completed in 1995. Other pollutants, including PCBs, mercury, and oil and grease, have contributed to use impairments, and there is a fish advisory in place for mercury and PCBs. An ecologically important shoreline in Marinette was designated and is protected as a Natural Area and a bulkhead line designation on the river shoreline in Marinette was removed.

The concentrations and extent of industrial contaminants led the International Joint Commission to designate the lower Fox River and southernmost Green Bay (which is in the adjacent Central Lake Michigan Coastal Ecological Landscape) as a Great Lakes Area of Concern. However, lesser concentrations of sediment contamination occur throughout the rest of Green Bay, which is within the Northern Lake Michigan Coastal Ecological Landscape. Also, the mouth of the Oconto River is affected by pollutants that originated with industrial discharges 30 miles upstream. A paper mill on the Oconto River discharged large volumes of various wastes from the 1890s through the 1970s. The worst contributor was sulfite/ammonia, beginning in 1931 when the pulp mill changes its process.

A 1988 Remedial Action Plan prepared by the Wisconsin DNR linked many use impairments to the presence of PCBs in river and bay sediments and identified goals, objectives, and a framework for conducting remedial actions in the Lower Fox River and in Green Bay (Wisconsin DNR 1988). A series of studies by the Wisconsin DNR and the U.S. Environmental Protection Agency concluded in the mid-1970s that PCBs in the Lower Fox River and Green Bay present an unacceptable level of risk to human health and the ecosystem (Wisconsin DNR and USEPA 2002). The conclusion that PCB levels are unacceptably high is also reflected in the fish consumption advisories that have been in place continuously for this region since the risks were first evaluated in 1976. The excess cancer risk and non-cancer health hazards associated with human ingestion of fish, as well as the ecological risks associated with ingestion of fish by birds, fish, and mammals, are above acceptable levels under baseline conditions (Wisconsin DNR and USEPA 2002). The legacy of this single contaminant remains and is being addressed through a program of dredging and sediment disposal (Wisconsin DNR 2009a).

Groundwater contamination problems have been documented for nearly 50 years. The underlying bedrock of the Door Peninsula and northeast Kewaunee County is fractured carbonate. This rock, combined with thin soils and agricultural land use practices makes this portion of this ecological landscape vulnerable to widespread groundwater contamination. While some problems and specific sites have been addressed, increased manure and whey land spreading, combined with continued well construction have led to widespread contamination of well water by coliform bacteria (*Escherichia coli*) and excessive nitrate. A multi-county, cross-agency task force has produced a series of recommendations to help landowners and local governments deal with pollution problems using a unified approach (Erb and Stieglitz 2007).

Biotic Environment

Vegetation and Land Cover

Historical Vegetation

Several sources were used to characterize the historical vegetation of the Northern Lake Michigan Coastal Ecological Landscape, relying heavily on data from the General Land Office's Public Land Survey (PLS), conducted in Wisconsin between 1832 and 1866 (Schulte and Mladenoff 2001). PLS data are useful for providing estimates of past forest composition and tree species dominance for large areas. Finley's (1976) map of historical land cover based on his interpretation of PLS data was also consulted. Additional inferences about vegetative cover were sometimes drawn from information on land capability, climate, disturbance regimes, the activities of native peoples, and various descriptive narratives. More information about these data sources is available in Appendix C, "Data Sources Used in the Book," in Part 3 ("Supporting Materials").

According to Finley's map and data interpretation, in the mid-1800s, the Northern Lake Michigan Coastal Ecological Landscape contained extensive areas of northern hardwood forest, which included American beech (*Fagus grandifolia*) and eastern hemlock (*Tsuga canadensis*) as major components. Swamp conifer made up 27% (343,000 out of 1,275,000 acres) of the ecological landscape (Figure 15.1), the largest percentage of this type in any ecological landscape (see Finley's presettlement vegetation map in Appendix G, "Statewide Maps," in Part 3 of the book).

PLS information has been converted to a database format, and relative importance values (RIV) for tree species calculated based on the average of tree species density and basal area (He et al. 2000). This analysis indicates that collectively, the northern hardwood species, including eastern hemlock (50.8% of the RIV) were the most dominant group in the Northern Lake Michigan Coastal Ecological Landscape. Within that group, eastern hemlock had the highest RIV (17.8%) followed by American beech (14.5%) and sugar maple (*Acer saccharum*) (10.0%). Outside of the northern hardwood species, eastern white pine (*Pinus strobus*) had the highest RIV (12.6%) followed by northern white-cedar (*Thuja occidentalis*) (11.8% of RIV). See the map entitled "Vegetation of the Northern Lake Michigan Coastal Ecological Landscape in the Mid-1800s" in Appendix 15.K at the end of this chapter.

Current Vegetation

There are several data sets available to help assess current vegetation at a broad scale in Wisconsin. Each was developed for different purposes and has its own strengths and limitations in describing vegetation. For the most part, WISCLAND, the Wisconsin Wetlands Inventory (WWI), the U.S. Forest Service's Forest Inventory and Analysis (FIA), and the National Land Cover Database (NLCD) were used. Results among these data sets often differ, as they are the products of different methodologies for classifying land cover, and each data set was compiled based on sampling or imagery collected in different years, sometimes at different seasons, and at different scales. In general, information was cited from the data sets deemed most appropriate for the specific factor being discussed. Information on data source methodologies, strengths, and limitations is provided in Appendix C, "Data Sources Used in the Book," in Part 3 ("Supporting Materials").

The Northern Lake Michigan Coastal Ecological Landscape is approximately 1,272,000 acres in size, of which approximately 34% was forested in 1992 (Wisconsin DNR 1993b). WISCLAND land use/land cover data from 1992 also indicates that 51% of the ecological landscape was in agricultural use at the time (over 650,000 acres). Forested and nonforested wetlands accounted for 20% of the area (Figure 15.2).

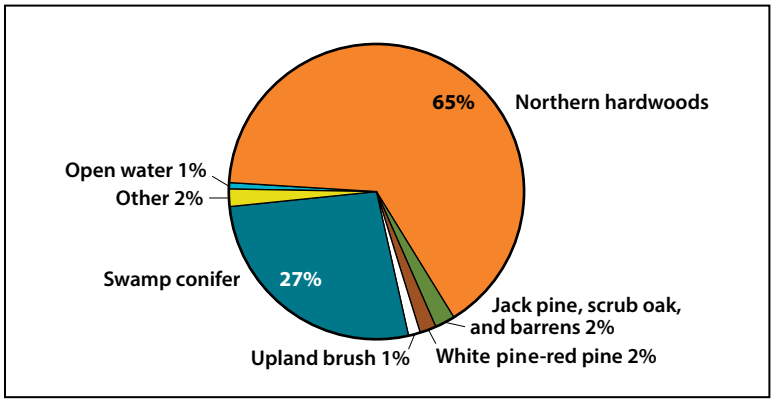


Figure 15.1. *Vegetation of the Northern Lake Michigan Coastal Ecological Landscape during the mid-1800s as interpreted by Finley (1976) from Public Land Survey information.*

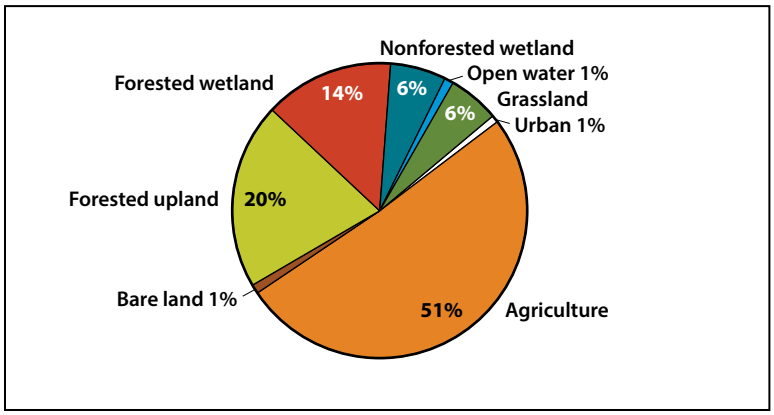


Figure 15.2. *WISCLAND land use/land cover data showing categories of land use classified from LANDSAT satellite imagery (1992) for the Northern Lake Michigan Coastal Ecological Landscape (Wisconsin DNR 1993b).*

According to the WWI, wetlands are common in the Northern Lake Michigan Coastal Ecological Landscape, comprising 20.4%, (approximately 262,000 acres) of the ecological landscape's vegetation (Wisconsin DNR 2010b). Forested wetlands make up nearly 214,000 acres of the ecological landscape, making these the most abundant wetland types in the Northern Lake Michigan Coastal Ecological Landscape. Shrub/scrub wetlands occur across more than 31,000 acres. Additional information on wetlands and wetland flora may be found in the "Natural Communities" and "Flora" sections of this chapter. Detailed information on wetland communities may be found in Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book.

According to FIA data summarized in 2004, approximately 62% of land area in the Northern Lake Michigan Coastal Ecological Landscape is nonforested, and about 38% is forested (USFS 2004). The predominant forest cover type group is northern hardwoods (27% of the land area), followed by lowland hardwoods (22% of the area of the land area) and aspen-birch (12% of the land area). All other forest types occupy 10% or less of the land area (Figure 15.3).

Changes in Vegetation over Time

The purpose of examining historical conditions is to identify ecosystem factors that formerly sustained species and communities that are now altered in number, size, or extent or that have been changed functionally (e.g., by constructing dams or suppressing fires). Although data are limited to a specific snapshot in time, they provide valuable insights into Wisconsin's ecological capabilities. Maintaining or restoring some lands to more closely resemble historical systems and including some structural or compositional components of the historical landscape within actively managed lands can help conserve important elements of biological diversity. We do not mean to imply that entire ecological landscapes should be restored to historical conditions, as this is not possible and not necessarily desirable within the context of providing for human needs and desires. Information on the methodology, strengths, and limitations of the vegetation change data is provided in Appendix C, "Data Sources Used in the Book," in Part 3.

Current forest vegetation (based on FIA) is primarily northern hardwood species, including sugar maple, white ash (*Fraxinus americana*), American basswood (*Tilia americana*),

and others) (27.0%), northern white-cedar (22.5% of RIV), and aspen-birch (13.9%) (Figure 15.4). Aspen (*Populus* spp.) has increased as compared with historical conditions from 6.8% to 13.9% of RIV, while red maple (*Acer rubrum*) has increased from 1.7% to 9.2%, and northern white-cedar has increased from 11.8% to 22.5%. Northern hardwood species have decreased from 50.8% to 27.0% of RIV, and tamarack (*Larix laricina*) has decreased from 5.4% to 1.4% of RIV.

The overall RIV of the different species of northern hardwoods has decreased from over 50% to 27%, and the RIVs of the individual species within that group have also changed widely (Figure 15.5). The RIVs of eastern hemlock, American beech, sugar maple, and yellow birch (*Betula alleghaniensis*) have all decreased, while ash (*Fraxinus* spp.) has increased.

The most dramatic change between the mid-1800s and the present has been the loss of the mesic hemlock-hardwood forest that once covered most of this ecological landscape, including the interior of the Door Peninsula, and its replacement by agricultural lands. Other significant changes include the loss of old forest, the change from conifer-dominated lowland forests west of Green Bay to dominance by broad-leaved deciduous species, intensive urban-industrial development at the mouths of the larger rivers, such as the Menominee and Oconto, and the explosive spread of invasive species in the wetlands and waters of Green Bay. The extent of the formerly vast wetlands bordering the west side of Green Bay has been diminished (Bosley 1978), and their composition has been significantly changed (Robinson 1994, Frieswyk and Zedler 2007).

Natural Communities

This section summarizes the abundance and importance of major ***physiognomic*** (structural) ***natural community groups*** in this ecological landscape. Some of the exceptional opportunities, needs, and actions associated with these groups, or with some of the individual natural communities, are discussed briefly. For details on the composition, structure, and distribution of the specific natural communities of this ecological landscape, see Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book. Information on invasive species can be found in the "Natual and Human Disturbances" section of this chapter.

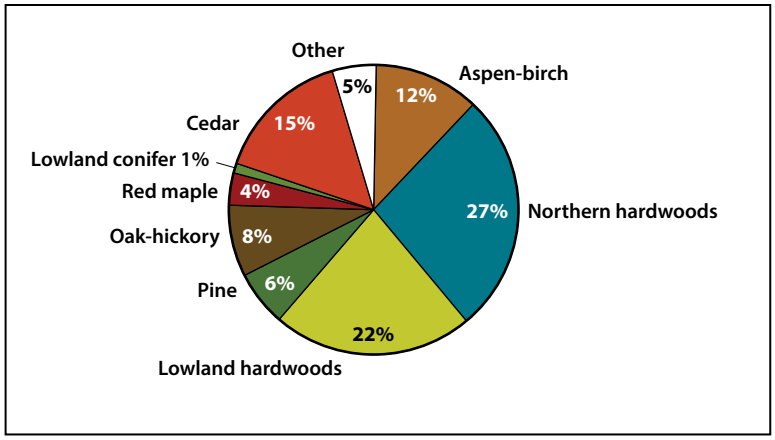


Figure 15.3. *Forest Inventory and Analysis data (USFS 2004) showing forest types as a percentage of forested land area (greater than 17% canopy cover) for the Northern Lake Michigan Coastal Ecological Landscape. The "pine" category includes eastern white, red, and jack pine. The "cedar" category is northern white-cedar. The "wetland conifer" category may also include some northern white-cedar because it is found in both upland and wetland sites here. See Appendix C, "Data Sources Used in the Book," in Part 3 of the book for more information about the FIA data.*

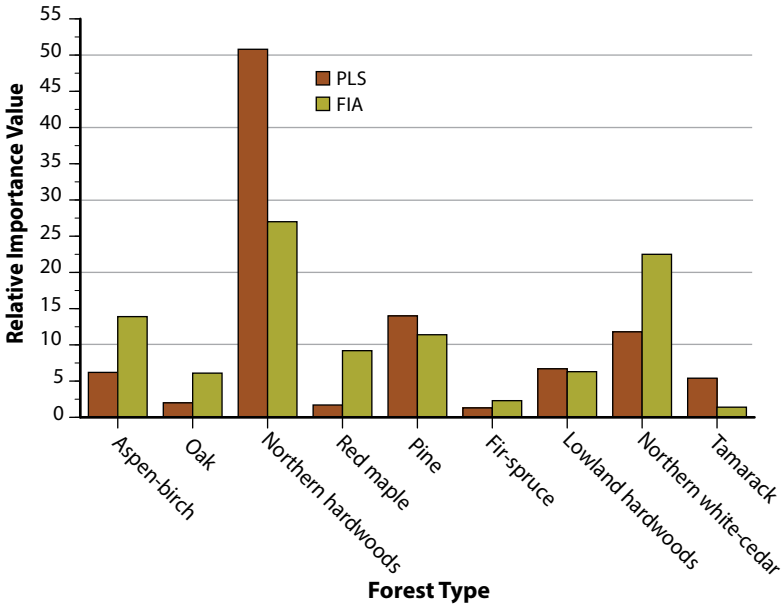


Figure 15.4. *Comparison of tree species' relative importance value (average of relative dominance and relative density) for the Northern Lake Michigan Coastal Ecological Landscape during the mid-1800s, when General Land Office Public Land Survey (PLS) data were collected, with 2004 estimates based on Forest Inventory and Analysis (FIA) data (USFS 2004). Each bar represents the proportion of that forest type in the data set (totals equal 100). Trees of less than six-inch diameter were excluded from the FIA data set to make it more comparable with PLS data. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the PLS and FIA data.*

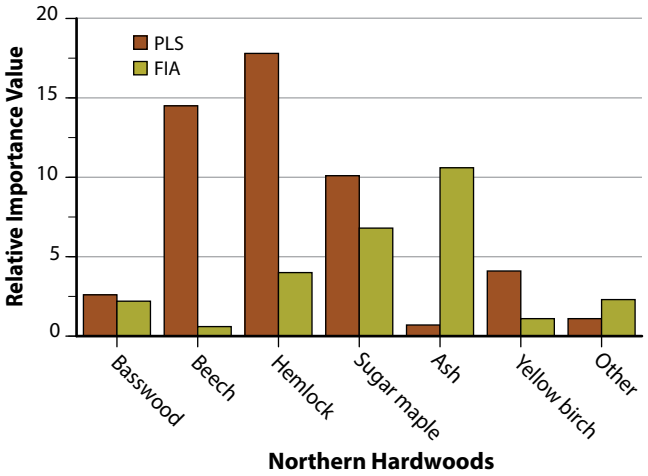


Figure 15.5. *Comparison of northern hardwoods species' relative importance value (average of relative dominance and relative density) for the Northern Lake Michigan Coastal Ecological Landscape during the mid-1800s, when General Land Office Public Land Survey (PLS) data were collected, with 2004 estimates based on Forest Inventory and Analysis (FIA) data (USFS 2004). Trees of less than six-inch diameter were excluded from the FIA data set to make it more comparable with PLS data. See Appendix C, "Data Sources Used in the Book," in Part 3 of the book for more information about the PLS and FIA data.*

Forests. Historically, forests covered the uplands throughout almost all of this ecological landscape, with mesic hardwood or hemlock-hardwood types the most abundant. Lowland forests were common in some areas and included acid conifer swamps of black spruce (*Picea mariana*) and tamarack, "rich" conifer swamps of northern white-cedar, ash-dominated hardwood swamps, and, at a few locations along the largest rivers, floodplain forests composed of deciduous species. Lowland forests were especially prominent in a broad zone that paralleled the west shore of Green Bay.

The interior of the Door Peninsula has been mostly converted to agricultural (or more recently, residential) uses. Remnants of the formerly extensive mesic forests now exist as farm woodlots, often isolated and altered by a variety of uses such as repeated logging and grazing. Some of the larger upland forest remnants occur in areas where the dolomite bedrock is close to the surface, which made those locations less suitable for intensive agriculture use. The proximity of bedrock to the surface poses special problems for those who manage water and waste materials and also presents challenges to forest managers. The largest forest remnants in the Peninsula's interior are mostly wet—either conifer swamps composed of northern white-cedar, balsam fir, tamarack, and black spruce or hardwood swamps made up of ashes, elms (*Ulmus* spp.), and "soft" maples (*Acer saccharinum*, *A. rubrum*, and their hybrids).

A coastal strip on the east side of the Peninsula remains heavily forested, though residential developments and associated infrastructure are rapidly fragmenting the forest remnants into smaller, less connected patches. Forest communities on the Door Peninsula are mostly mesic, with localized areas of boreal forest in which white spruce, northern white-cedar, balsam fir, and eastern white pine are important and limited areas of dry-mesic oak and pine forest reflecting unusual edaphic conditions (such as those associated with dunes or ancient beach ridges). Lowland forests dominated by conifers or ashes occur in areas of poorly drained moraine, along streams and in lake basins, and in a few localities (such as the swales associated with coastal ridge-and-swale systems, or in low spots on old beach terraces) along Lake Michigan and Green Bay.

The west shore of Green Bay still supports extensive areas of second-growth lowland forest, which are now dominated by hardwoods such as ashes and red maple rather than the historically dominant conifers (which still persist, but in reduced abundance). The largest of these west shore swamps occupies roughly 10,000 acres on the Marinette-Oconto county line. Several miles of the lower Peshtigo River are bordered by Floodplain Forest, which here and along the lower Menominee River on the Wisconsin-Michigan state line is very near its northern range limits. Some "southern" animals (e.g., birds) are associated with these forested floodplains.

A concentration of rich conifer swamps, dominated by northern white-cedar and/or tamarack, occurs east and north of Lake Noquebay in Marinette County, to the Menominee River. Black ash (*Fraxinus nigra*) dominated hardwood swamps and alder (*Alnus* spp.) dominated shrub swamps are also common in this part of the ecological landscape. Stands of Floodplain Forest occur in this part of the ecological landscape within the Menominee River floodplain, often in association with riverine lakes (oxbows, running sloughs, cutoff channels, and floodplain ponds).

Dry forests composed of oaks (*Quercus* spp.) and/or pines (*Pinus* spp.) are not widespread here, but they are locally common in areas characterized by relatively infertile sandy soils. One of these areas occurs south and east of Oconto Falls around an impounded stretch of the Oconto River (near the Machickanee Flowage), south to the Pensaukee River. Pines, aspens, and oaks are the dominant trees. The other area that formerly contained extensive dry forests is north of the Peshtigo River between the cities of Peshtigo and Marinette. This was one of the areas that burned severely during the Peshtigo Fire of 1871. Residential and agricultural developments have significantly fragmented the formerly extensive forests in this area.

Savannas. With the notable exception of the Pine Barrens, the vast majority of savanna communities occurred in regions along or south of the Tension Zone or in areas of extensive outwash sands that burned frequently prior to Euro-American settlement. Concentrations of

barrens remnants have been documented in the Northeast Sands, Northwest Sands, and Central Sand Plains ecological landscapes. Scattered occurrences are found elsewhere in the state, often associated with river terraces and/or sandy glacial outwash deposits.

A single, very small example of Great Lakes Barrens has been described from the coast of 2,800-acre Chambers Island in Green Bay. At least one additional barrens occurrence has been recently reported from the Green Bay West Shores State Wildlife Area (Pensaukee Unit), and it is possible that a few other barrens-like remnants occur in areas of sandy, infertile soils west of Green Bay. These would most likely be small and in need of restoration actions. Several highly degraded examples of Alvar have been noted on the eastern Door Peninsula. These can bear a structural resemblance to savannas when they include scattered open-grown trees interspersed with open shrub- and herb-dominated patches.

Shrub Communities. Shrub swamps are widespread and abundant in the poorly drained lowlands west of Green Bay, including the upper margins of the west shore wetlands, where more "southern" Shrub-carr community types are now apparently more common than Alder Thicket. Elsewhere in this ecological landscape, Alder Thicket is widespread, often forming a distinct vegetation zone along stream, lake, or wetland borders. The area east and north of Lake Noquebay is very poorly drained and contains extensive wetlands. Alder Thicket is the dominant tall shrub community type there, but hard data on the extent, composition, and condition of native shrub communities in this portion of the Northern Lake Michigan Coastal Ecological Landscape are scarce.

Herbaceous Communities. Extensive emergent marshes comprise the dominant vegetation in many of the wetlands along Green Bay's west shore. In recent decades, there has been a radical shift in species dominance, where robust, highly invasive species such as common reed, narrow-leaved or hybrid cat-tails, reed canary grass (*Phalaris arundinacea*), and purple loosestrife (*Lythrum salicaria*) have recently replaced the native emergent broad-leaved cat-tail (*Typha latifolia*), bulrushes (*Schoenoplectus* spp., *Scirpus* spp.), arrowheads (*Sagittaria* spp.), and bur-reeds (*Sparganium* spp.) in many areas.

Sedge meadows tend to occur in areas that are saturated or partially inundated for relatively brief periods of time rather than frequently inundated for extended periods. On the west shore, encroachment of sedge meadows by woody species such as willows (*Salix* spp.), dogwoods (*Cornus* spp.), ashes, elms, eastern cottonwood (*Populus deltoides*), or balsam poplar (*Populus balsamifera*) is common, especially in stands that have been ditched or otherwise partially drained. Fire suppression and, in some areas, perhaps groundwater withdrawals may also play a role in the conversion of sedge meadow to shrub swamp or lowland hardwood dominance. Extensive meadows still occur in some areas of this ecological landscape, such as Peshtigo Harbor Unit of the Green Bay West Shores State Wildlife Area.

Sedge meadows also occur in some of the coastal wetlands along the Door Peninsula and in small patches on several of the Grand Traverse Islands. Some of these meadows are alkaline and fen-like and should be sampled to better document their composition and to search for rare biota. The meadows bordering the Mink River are part of a large freshwater estuary complex (intact estuarine wetlands are now rare anywhere in the Wisconsin waters of Lake Michigan, as many of the river mouths are now occupied by cities, and many of the wetlands have been filled).

Fens in this ecological landscape lack many of the prairie components of calcareous fens in southern Wisconsin, but, like them, they are strongly alkaline and may harbor rare calciphiles that occur in few other habitats. Because of the requirement for calcareous groundwater, the fens documented in this ecological landscape occur either on the Door Peninsula or in the Grand Traverse Islands, in wetlands where

Northern Sedge Meadow and Emergent Marsh at Seagull Bar lagoon, Marinette County. Photo by Emmet Judziewicz.

Interdunal Wetland and Boreal Forest, fen-like wetlands on pool margins. Jackson Harbor Ridges State Natural Area, Washington Island, Door County. Photo by Eric Epstein, Wisconsin DNR.

the calcareous substrate of dolomite or glacial till derived from dolomite influences the chemical composition of the groundwater. Given the calcareous nature of the till here, it is possible that fens may be found in other parts of this ecological landscape as well.

Beaches and dunes occur along parts of the Door Peninsula's Lake Michigan coast and on several of the Grand Traverse Islands. They provide habitat for rare species, including plants endemic to Great Lakes shorelines such as dune thistle (Pitcher's thistle) (*Cirsium pitcheri*) and dune goldenrod (*Solidago simplex* var. *gillmann*). During those periods when the water levels of Lake Michigan are low, extensive exposures of sand and mud may occur in locations such as the Peshtigo River delta in Marinette County, creating important, if temporary, habitat for plants that may colonize primary habitats and for shorebirds and other migratory species.

Though this ecological landscape historically lacked native terrestrial grasslands such as prairies, some agricultural lands on the east side of the Door Peninsula, especially hay fields and pastureland, were formerly quite productive for grassland birds. For example, the Wisconsin breeding bird atlas (Cutright et al. 2006) shows one of the state's few breeding concentrations for the Wisconsin Special Concern species Upland Sandpiper (*Bartramia longicauda*) on the Door Peninsula. This is probably due to the cool climate and somewhat delayed or retarded growing season near Lake Michigan, which set back the cutting of hay (elsewhere in Wisconsin, for example, hay may now be cut as early as mid-May, giving very few bird species a chance to successfully bring off young). Livestock may be turned out into pastures later here than at many other locations in the state. In recent years there has been an increase in residential construction in former agricultural areas. If these trends continue, few if any grassland birds will find suitable nesting habitat in the uplands of this ecological landscape.

Fen grass-of-Parnassus and the Wisconsin Special Concern lesser fringed gentian are among the unusual plants growing in this semi-shaded alkaline swale near Lake Mighigan on the northeastern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

Geological Features. At several locations adjoining Lake Michigan on the eastern side of the Door Peninsula, past lake levels have created alternating series of ridges and swales that parallel the shoreline. The sandy ridges support a variety of forest communities; the swales typically contain wetland vegetation, or even open water, and moisture conditions are either saturated or inundated. The biota associated with the ridge-and-swale complexes is extremely diverse, owing to the complexity of the vegetation mosaic and proximity of such features to Lake Michigan.

Intact freshwater estuaries are uncommon features on Wisconsin's Lake Michigan shore, but several of the state's best examples occur in the Northern Lake Michigan Coastal Ecological Landscape. Embayment lakes are also uncommon coastal features, and these occur where former bays of Lake Michigan have been cut-off from the lake by the development of a baymouth bar as water levels dropped. Ridge-and-swale landforms may develop if water levels have successively dropped several times and then remained relatively stable for long enough periods.

Great Lakes Estuary, Mink River, Rowley's Bay, northeastern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

Fish Island is Wisconsin's easternmost point of land. This unvegetated island is composed mostly of dolomite cobbles. Photo by Emmet Judziewicz.

Beach and dune complexes occur at scattered locations along the Lake Michigan shore, and these rely on a constant source of sand so that they are not "starved" of the sediments needed to replenish them. Residential development and heavy recreational use of beach and dune habitats present many challenges for managers. Several of the Great Lakes regional endemics rely on relatively intact, functional beach and dune systems as their primary, or in some cases only, suitable habitat. Such habitats are fragile and highly threatened.

Dolomite cliffs are prominent landscape features associated with some stretches of the Niagara Escarpment, which runs along the western edge of the Door Peninsula and also forms headlands with cliffs on some of the Grand Traverse Islands. In some areas, especially along the east side of the northern Door Peninsula, exposures of level dolomite occur as Great Lakes Alkaline Rockshore. The amount of exposed rock varies with the level of Lake Michigan. Dolomite also outcrops as low ledges at several locations on the eastern Door Peninsula. Cave Point County Park, south of Jacksonport, features a long series of low dolomite cliffs and ledges one to three meters high.

Islands of the Grand Traverse archipelago occur in the Great Lakes waters off of the Door Peninsula. The islands range in size from 14,320-acre Washington Island to 1.2-acre Fish Island. Silurian dolomite bedrock underlies most of these (Chambers, Green, and Fish islands are among the exceptions) and forms prominent cliffs on the north and northwest sides of some of these islands, dipping gently eastward to form bedrock and cobble shores on the eastern sides. These features provide critical nesting habitat for a number of birds. Chambers Island occurs in northern Green Bay, roughly seven miles northwest of the village of Fish Creek. Unlike other islands in the Grand Traverse group, it is low and sandy, featuring extensive, though narrow, sand beaches and low dune ridges. Dolomite bedrock underlies this island but exposures are apparently absent. Chambers is the second largest of the Grand Traverse Islands in Wisconsin and is almost entirely privately owned.

Great Lakes Alkaline Rockshore and Boreal Forest, south end of Toft Point, Door County. Photo by Eric Epstein, Wisconsin DNR.

There are submerged dolomite reefs and rocky shoals in Lake Michigan east and north of Baileys Harbor that constitute major spawning grounds for the still abundant and commercially important lake whitefish.

Forest Habitat Types

The Northern Lake Michigan Coastal Ecological Landscape contains a great variety of site types and many potential community types. The area west of Green Bay is fairly developed, and the best soils are often farmed, but forested areas still occur across diverse sites. The Door Peninsula is a unique ecosystem containing unusual site and community types; only the more common sites characteristic of the forested matrix have classified habitat types. Within the ecological landscape, common habitat type groups include wet-mesic to wet, mesic to wet-mesic, mesic, and dry-mesic (Table 15.1).

Wet-mesic to wet forested lowlands typically occur on poorly drained peat and muck soils. On nutrient medium to rich sites, stands may be dominated by swamp hardwoods or swamp conifers. Northern white-cedar is exceptionally common within this ecological landscape. On nutrient poor to medium sites, most stands are dominated by swamp conifers.

Mesic to wet-mesic sites are typically associated with loamy soils that are somewhat poorly drained and nutrient medium to rich. Conifer-dominated stands are common, particularly on nutrient-medium sites, and frequently dominated by a mixture of balsam fir, white spruce, eastern white pine, northern white-cedar, eastern hemlock, and red maple. Hardwood-dominated overstories also are common: typical associations include aspen–white birch–red maple; ashes–red maple; and red maple–sugar maple–American basswood–ashes–yellow birch. Potential late-successional dominants are eastern hemlock, sugar maple, and red maple, accompanied by yellow birch, ashes, American basswood, and balsam fir.

Mesic sites are typically associated with loamy soils that are well to moderately well drained, and nutrient medium to rich. Most stands are dominated by aspen and white birch (*Betula papyrifera*) or some mix of sugar maple, American beech, northern red oak (*Quercus rubra*), red maple, American basswood, white ash, and yellow birch. Late-successional stands are dominated by any mix of sugar maple, American beech, and eastern hemlock.

Dry-mesic sites are typically associated with loamy soils that are well drained and nutrient medium. Most stands are

Table 15.1. *Forest habitat type groups and forest habitat types[a] within the Northern Lake Michigan Coastal Ecological Landscape (NLMC EL).*

Northern forest habitat type groups common within NLMC EL[b]	Northern forest habitat types common within NLMC EL[b]	Northern forest habitat types minor within NLMC EL[b]
Wet-mesic to wet (WM-W)	Forest Lowland (habitat types not defined)	
Mesic to wet-mesic (M-WM)	TMC	Undefined wet-mesic ATAtOn ArAbVC
Mesic (M)	ATFD AFVb	AFAl ATFSt AFAd
Dry-mesic (DM)	AVb	ATFPo TFAa
Northern forest habitat type groups minor within the NLMC EL		
Dry to dry-mesic (D-DM)		PArVAa-Vb PArVPo

Source: Kotar and Burger (2002).

[a]Forest habitat types are explained in Appendix 15.B ("Forest Habitat Types in the Northern Lake Michigan Coastal Ecological Landscape") at the end of this chapter.

[b]Groups listed in order from most to least common:
Common occurrence is an estimated 10–50% of forested land area.
Minor occurrence is an estimated 1–9% of forested land area.
Present – Other habitat types can occur locally, but each represents < 1% of the forested land area of the ecological landscape.

dominated by aspen and white birch, or northern red oak and red maple, often with an ***admixture*** of eastern white pine, white ash, American basswood, sugar maple, American beech, or eastern hemlock. Late-successional stands are dominated by any mix of sugar maple, American beech, and eastern hemlock, accompanied by red maple, white ash, and American basswood.

Flora

Despite its relatively small size, the Northern Lake Michigan Coastal Ecological Landscape has a rich flora and supports many rarities. Only three much larger ecological landscapes (Western Coulees and Ridges, Southeast Glacial Plains, and North Central Forest) are known to support greater or roughly equivalent numbers of rare plant species (Wisconsin DNR 2009b).

The rare flora of this ecological landscape includes 14 species listed as Wisconsin Endangered, 22 listed as Wisconsin Threatened, and 66 listed as Wisconsin Special Concern on the Wisconsin Natural Heritage Inventory Working List (Wisconsin DNR 2009b). Two plants, dune thistle (Pitcher's thistle) and dwarf lake iris (*Iris lacustris*), listed as Wisconsin Threatened, are also listed as U.S. Threatened by the U.S. Fish and Wildlife Service. Several populations of these species (both endemic to shoreline habitats around the Great Lakes) are now monitored annually at sites on the Door Peninsula. A federal recovery plan has been completed for Pitcher's thistle (USFWS 2002). Approval for the dwarf lake iris recovery plan is pending approval, at least as of 2011.

The two U.S. Threatened species and several other plants occurring in this ecological landscape are considered globally rare by NatureServe, with a rank of G3 or higher (NatureServe 2009) (ranks with lower numbers indicate species or ecological communities that are rarer and at higher risk of extinction). These include spoon-leaf moonwort (*Botrychium spathulatum*), ram's-head lady's-slipper (*Cypripedium arietinum*), and Wolf's spikerush (*Eleocharis wolfii*).

Forested habitats of the Door Peninsula support many rare plant species, including plants of boreal affinity such as ram's-head lady's-slipper, northern comandra (*Geocaulon lividum*), and the unusual ***saprophyte***, giant pine-drops (*Pterospora andromedea*). Mesic forests of the Door Peninsula support most of the state's known populations (16 of 22 known populations) of long-spurred violet (*Viola rostrata*). A population of the extremely rare Wisconsin Endangered heart-leaf foam-flower (*Tiarella cordifolia*) was located recently in a mesic forest remnant near Lake Michigan. Chilean sweet cicely (*Osmorhiza berteroi*) is known in Wisconsin from a few stations on the Door Peninsula and several others near Lake Superior (including the Apostle Islands).

One of the most recent additions to Wisconsin's vascular flora was, surprisingly, a tree. Striped maple, aka "moosewood"

Giant pinedrops (Wisconsin Endangered) is extremely rare in Wisconsin, where it occurs at only a few locations. The Boreal Forests of the northern Door Peninsula provide habitat for this species. Photo by Kitty Kohout.

(*Acer pensylvanicum*), was discovered in September of 1997 by M. Grimm in a shoreline forest near Newport at the Door Peninsula's northern tip. Specimens and photos are housed at the Freckmann Herbarium at the University of Wisconsin-Stevens Point. This should serve as a caution for those inclined to treat past inventories as static efforts that had produced complete data sets—even in a locality as frequently visited and well botanized as Door County. To meet various societal needs and, especially, to improve our ability to make the best conservation decisions that yield the greatest return for our investments, inventories must be periodically updated and revised to meet changing circumstances.

The marshes, meadows, and fens of the Door Peninsula often show the influence of alkaline substrates and groundwater by the presence of calciphilic plants. Examples of these include shrubby cinquefoil (*Pentaphylloides floribunda*), Kalm's (or shrubby) St. John's-wort (*Hypericum kalmianum*), and Kalm's lobelia (*Lobelia kalmii*) as well as rarities such as slender-leaved sundew (*Drosera linearis*), livid sedge (*Carex*

Significant Flora in the Northern Lake Michigan Coastal Ecological Landscape

- The Door Peninsula and nearby Grand Traverse Islands support an especially high diversity of rare vascular plants.
- Large populations of plants endemic to Great Lakes shoreline habitats, such as dwarf lake iris and dune (Pitcher's) thistle, occur here.
- Complex and dynamic landforms along the Lake Michigan coast (beach and dune, ridge and swale, bedrock shore, interdunal wetland, freshwater estuary) support rare communities that in turn provide habitat for rare and highly specialized plants.
- The diverse flora of the shoreline habitats includes elements of boreal forest, fen, rock outcrops, wet meadow, and marsh as well as many species of wide distribution in the mixed conifer-hardwood forests of northern Wisconsin and Upper Michigan.
- Invasive plants are now well established on the Door Peninsula; several of these pose serious threats to the native flora.
- Invasive plants such as common reed and narrow-leaved cat-tail are now dominant in marsh and wet meadow habitats along Green Bay's west shore. This has reduced native plant diversity, altered structure, and lowered habitat values for some wildlife.
- Garlic mustard poses a serious threat to mesic forests throughout this ecological landscape.
- The abundant ***minerotrophic*** wetlands east and north of Lake Noquebay have not been surveyed in detail and merit more attention.
- Monitoring needs are high for rare plants, invasive species, floristically rich habitats, and habitats supporting plants sensitive to excessive deer impacts (yew, hemlock, white cedar, orchids).
- Effective invasive plant control will require multi-jurisdictional planning, coordination, and research, and long-term financial support.
- Increased development, the rapid spread of invasive species, disrupted dynamics in Lake Michigan and Green Bay, and global climate change present major challenges to managers and conservationists working to maintain native plants and the habitats upon which they are dependent.
- Severely disrupted natural communities may be on successional trajectories that are poorly understood, making the restoration of native flora in damaged ecosystems especially problematic.

livida), tufted bulrush (*Trichophorum cespitosum,* listed as *Scirpus cespitosus* on the Wisconsin Natural Heritage Woring List), common bog arrow-grass (*Triglochin maritima*), and slender bog arrow-grass (*T. palustre*).

Submergent Marsh habitats along the Great Lakes support unusual aquatic macrophytes such as the Wisconsin Endangered lake cress (*Armoracia lacustris*), mare's-tail (*Hippuris vulgaris*), and marsh mermaid-weed (*Proserpinaca palustris*).

Beach and dune habitats are most common on western Lake Michigan and best developed on the margins of the Door Peninsula and to a lesser degree at a few locations on the west shore of Green Bay. Dune thistle (Pitcher's thistle), a Great Lakes endemic, occurs in no other habitats. The Wisconsin Endangered Lake Huron tansy (*Tanacetum huronense*) is an extremely rare inhabitant of open dunes and shoreline bedrock habitats. Two Wisconsin Threatened plants, sand-reed grass (*Calamovilfa longifolia* var. *magna*) and dune goldenrod, also inhabit dunes and sometimes the upper beach zone, along with other rare or uncommon specialists such as seaside spurge (*Chamaesyce polygonifolia,* listed as *Euphorbia polygonifolia* in the Wisconsin Natural Heritage Working List), and American sea-rocket (*Cakile edentula*). Wisconsin's only known population of the globally rare Wisconsin Special Concern species, spoon-leaf moonwort, occurs in an open coastal habitat along Lake Michigan.

The Great Lakes Alkaline Rockshore community is geographically limited to parts of the Northern Lake Michigan Coastal Ecological Landscape where it occurs only on the Door Peninsula and in the Grand Traverse Islands. The (currently) extensive alkaline rockshores on the northeast side of the Door Peninsula are notable for supporting rare plants of restricted distribution. These include beach specialists such as silver-weed (*Argentina anserina*), endemics such as dwarf lake iris, disjuncts such as birds-eye (or Arctic) primrose (*Primula mistassinica*), and an interesting group of species that also occur in the calcareous fens and alkaline prairies of southeastern Wisconsin such as lesser fringed gentian (*Gentianopsis procera*), Ohio goldenrod (*Solidago ohioensis*), and sticky false-asphodel (*Triantha glutinosa,* listed as *Tofieldia glutinosa* on the Natural Heritage Working List). Since the last period of high water on Lake Michigan in the mid-1980s, there has been a great deal of bedrock shore exposed. In the

Alkaline Emergent Marsh, Washington Island, Door County. Photo by Emmet Judziewicz.

Shallow bay of Lake Michigan, Great Lakes Alkaline Rockshore, mixed boreal X northern hardwoods forest. Northern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

Dune thistle is an extreme habitat specialist restricted to intact dune systems along the shores of the Great Lakes. This globally rare plant is U.S. Threatened. Photo by Kitty Kohout.

short-term, this creates excellent opportunities to botanize these habitats, but in the absence of periodic inundation, it is likely that successional processes and an increase in tall, rank vegetation would diminish or even eliminate populations of some of the open shoreline specialists.

The Niagara Escarpment, with its exposures along the west side of the Door Peninsula and on several of the Grand Traverse Islands, also provides habitat for specialists, some of them very rare. Besides the previously mentioned lanceolate whitlow-cress, other rarities strongly associated with the escarpment include rock whitlow-grass (*Draba arabisans*), climbing fumitory (*Adlumia fungosa*), and Wisconsin's only stations for broad-leaf sedge (*Carex platyphylla*). Shining lady's-tresses (*Spiranthes lucida*) has recently been discovered growing near the northern edge of the ecological landscape in shallow soils over calcareous bedrock near the Menominee River. The rare aquatic macrophyte and Wisconsin Endangered lake cress has been located at one site in the Northern Lake Michigan Coastal Ecological Landscape in an impounded stretch of the Peshtigo River.

Judziewicz (2001) described natural communities and plant habitats found throughout the Grand Traverse archipelago, along with a history of botanical collecting in the islands. His article "Flora and Vegetation of the Grand Traverse Islands (Lake Michigan), Wisconsin and Michigan" (Judziewicz 2001) is an excellent reference and resource on flora and vegetation for all land managers, botanical researchers, and plant enthusiasts in this region, including those on the mainland.

Fauna

Changes in Wildlife over Time

Many wildlife populations have changed dramatically since humans arrived on the landscape, but these changes were not well documented before the mid-1800s. This section discusses only those wildlife species documented to have occurred in the Northern Lake Michigan Coastal Ecological Landscape. Of those, this review is limited to species that were known, or thought to be, especially important here in comparison to other ecological landscapes. For a more complete review of historical wildlife in the state, see a collection of articles written by A.W. Schorger, compiled into the volume *Wildlife in Early Wisconsin: a collection of works by A.W. Schorger* (Brockman and Dow 1982).

The North Lake Michigan Coastal Ecological Landscape was important historically for northern forest wildlife species, including American black bear (*Ursus americanus*), bobcat (*Lynx rufus*), American beaver (*Castor canadensis*), and North American river otter (*Lontra canadensis*) (see Chapter 12, "North Central Forest Ecological Landscape," for a historical description of these species). Neotropical migrant birds and forest raptors were likely important in this ecological landscape as were Bald Eagle (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*) (see Chapter 14, "Northern Highland Ecological Landscape," for historical information on the latter two species). Great Lakes shoreline species such as gulls, terns, cormorants, shorebirds, and other waterbirds were also probably important. As forests were logged in the late 19th and early 20th centuries and the ecological landscape was inhabited by Euro-American settlers, wildlife populations changed.

Historically, the American beaver was present in this ecological landscape, as it was across the state. As elsewhere in Wisconsin, beaver populations declined dramatically with unregulated trapping and hunting for the fur trade through the 1700s and into the mid-1800s (Schorger 1965). Beaver populations have now recovered, and they are again present in the ecological landscape.

Based on trapping records, the North American river otter was historically as abundant or more abundant than the beaver across the state (Schorger 1970). Similar to what happened with the beaver, otter populations also declined dramatically throughout the state with unregulated trapping for the fur trade. Today otter populations have recovered and are again present in the Northern Lake Michigan Ecological Landscape.

White-tailed deer (*Odocoileus virginianus*) were found throughout the state in the mid-1800s. The northern part of Door County was especially good for deer (Schorger 1953). Deer were killed in "immense numbers," and venison was shipped south through Kewaunee in 1880 (Schorger 1953). Five years later, deer were considered scarce in that area. The deer population expanded and increased in northern Wisconsin after large-scale logging took place in the late 1800s (Schorger 1953) (see Chapter 12, "North Central Forest Ecological Landscape," for a more complete description of historical deer populations). However, the large number of settlers who followed the loggers depended on venison for food. Subsistence harvest, together with market hunting, likely reduced the state deer population to its lowest level around the turn of the 20th century. Hunting regulations were begun in 1897, but it was not until the 1920s that overshooting of the deer herd was curbed. Today deer populations in this ecological landscape are large compared to populations prior to Euro-American settlement. Relatively mild winters during the decades of the 1990s and 2000s have increased winter survival and allowed the deer herd to increase. The deer herd in the eastern farmland deer management region has often been above goal (Figure 15.6), and overbrowsing of more palatable plants is becoming common in much of this ecological landscape.

The American black bear was abundant throughout the northern and central parts of the state but also found, though with less frequency, in the southern part of the state. By the late 1880s, the black bear was gone from the southeastern part of the state and by 1901 had disappeared from Door County. However, they remained in the western part of the ecological landscape, in Oconto and Marinette counties (Schorger 1949). Today the black bear is again found throughout the Northern Lake Michigan Coastal Ecological

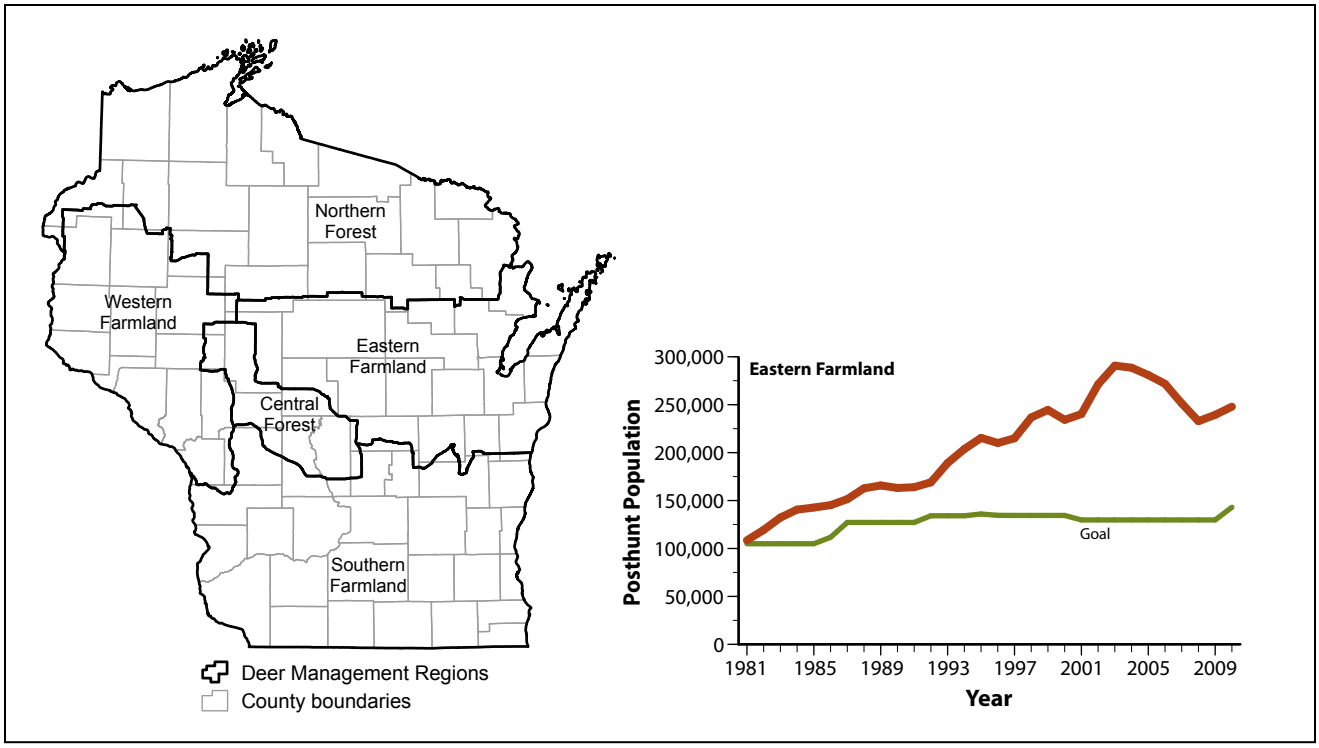


Figure 15.6. *White-tailed deer population size in relation to population goals in the eastern farmland deer management region.*

Landscape (see Chapter 12, "North Central Forest Ecological Landscape," for a more complete description of historical black bear populations).

The Ruffed Grouse (*Bonasa umbellus*) was found throughout the state prior to Euro-American settlement. It was not common in the northern part of the state where old coniferous and hardwood forests predominated (Schorger 1945) (see Chapter 12 for a more complete description of historical Ruffed Grouse populations). Ruffed Grouse populations increased in the north as lumbering took place during the latter half of the 19th century. After the coniferous trees were cut, a younger, hardwood-dominated forest habitat became established that was more favorable for Ruffed Grouse. Today Ruffed Grouse are common throughout forested portions of this ecological landscape.

Significant Wildlife

Wildlife are considered significant for an ecological landscape if (1) the ecological landscape is considered important for maintaining the species in the state and/or (2) the species provides important recreational, social, and economic benefits to the state. To ensure that all species are maintained in the state, "significant wildlife" includes both common species and species that are considered "rare." Four categories of species are discussed: rare species, Species of Greatest Conservation Need, responsibility species, and socially important species (see definitions in text box). Because the conservation of wildlife communities and habitats is the most efficient way to manage and benefit a majority of species, we also discuss management of different wildlife habitats in which significant fauna occur.

Rare Species. "Rare" animals include all of those species that appear on the Wisconsin Natural Heritage Working List and are classified as "Endangered," "Threatened," or "Special Concern" by the state or federal governments. As of November 2009 (Wisconsin DNR 2009b), the Natural Heritage Inventory documented 106 rare animal species, including 2 mammals, 29 birds, 7 herptiles, 12 fishes, and 56 invertebrates within the Northern Lake Michigan Coastal Ecological Landscape. These include two U.S. Endangered species, 14 Wisconsin Endangered species, 16 Wisconsin Threatened species, and 76 Wisconsin Special Concern species. See Appendix 15.C for a complete list of rare animals occurring in the Northern Lake Michigan Coastal Ecological Landscape; see Appendix 15.D for the number of species per taxon with special designations documented within the Northern Lake Michigan Coastal Ecological Landscape.

Federally Listed Species: Two U.S. Endangered animals occur in this ecological landscape. One is the Piping Plover (*Charadrius melodus*), which is also listed as a Wisconsin Endangered species. The other is the Hine's emerald dragonfly (*Somatochlora hineana*), also listed as a Wisconsin Endangered species. The Bald Eagle (U.S. Threatened until very recently) is found here. After its recent delisting, the species is now federally protected with required monitoring for five years to ensure that the population does not decline.

The Bald Eagle is further protected under the U.S. Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The Bald Eagle is now listed as a Wisconsin Special Concern species.

The gray wolf (*Canis lupis*), which occurs in this ecological landscape, was removed from the federal threatened species list in January 2012, granting management authority to the State of Wisconsin. The Wisconsin state legislature passed a law in April 2012 authorizing hunting and trapping seasons for wolves and directed that wolf hunting and trapping seasons be held starting in the fall of 2012. The first hunting and trapping seasons of wolves were conducted during October-December 2012. Wolves are now being managed under a 1999 wolf management plan (Wisconsin DNR 1999) with addenda in 2006 and 2007, but the plan is being updated to reflect these recent changes in wolf management in Wisconsin.

Wisconsin Endangered Species: No Wisconsin Endangered mammals or fish occur in this ecological landscape. Seven Wisconsin Endangered birds occur here, including Piping Plover, Loggerhead Shrike (*Lanius ludovicianus*), Red-necked Grebe (*Podiceps grisegena*), Caspian Tern (*Hydroprogne caspia* but listed as *Sterna caspia* on the Wisconsin Natural Heritage Working List), Forster's Tern (*Sterna forsteri*), Common Tern (*Sterna hirundo*), and Barn Owl (*Tyto alba*). Other Wisconsin Endangered species found here include two herptiles, northern cricket frog (*Acris crepitans*) and eastern ribbonsnake (*Thamnophis sauritus*); one mussel, the snuffbox, and four other invertebrates—swamp metalmark butterfly (*Calephelis muticum*), Hine's emerald dragonfly, Midwest Pleistocene vertigo terrestrial snail (*Vertigo hubrichti*), and Lake Huron locust (*Trimerotropis huroniana*).

Wisconsin Threatened Species: No Wisconsin Threatened mammals occur in this ecological landscape. Five Wisconsin Threatened birds occur in this ecological landscape, including Henslow's Sparrow (*Ammodramus henslowii*), Great Egret (*Ardea alba*), Red-shouldered Hawk (*Buteo lineatus*), Yellow Rail (*Coturnicops noveboracensis*), and Hooded Warbler (*Setophaga citrina* but listed as *Wilsonia citrina* on the Natural Heritage Working List). Two Wisconsin Threatened herptiles, wood turtle (*Glyptemys insculpta*) and Blanding's turtle (*Emydoidea blandingii*), have been documented here. Four Wisconsin Threatened fish are listed in the NHI database for the Northern Lake Michigan Coastal Ecological Landscape, including longear sunfish (*Lepomis megalotis*), redfin shiner (*Lythrurus umbratilis*), greater redhorse (*Moxostoma valenciennesi*), and pugnose shiner (*Notropis anogenus*), but recent surveys have documented two other Wisconsin Threatened fish here in the Wolf River, the shoal chub (*Macrhybopsis hyostoma*) and river redhorse (*Moxostoma carinatum*). These records have not yet been added to the NHI database so they are not reflected in the number of Wisconsin Threatened fish above. Three Wisconsin Threatened mussels have been documented here, including slippershell mussel (*Alasmidonta viridis*), salamander mussel (*Simpsonaias ambigua*), and buckhorn (*Tritogonia verrucosa*), in addition to two other Wisconsin Threatened invertebrates, pygmy snaketail dragonfly (*Ophiogomphus howei*) and cherrystone drop terrestrial snail (*Hendersonia occulta*).

Wisconsin Special Concern Species: Wisconsin Special Concern species include 2 mammals, 17 birds, 3 herptiles, 8 fish, and 46 invertebrate species.

Species of Greatest Conservation Need. Species of Greatest Conservation Need (SCGN) appear in the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b) and include those species already recognized as Endangered, Threatened, or Special Concern on state or federal lists along with nonlisted species that meet the SGCN criteria. There are 8 mammals, 53 birds, 6 herptiles, and 8 fish species listed as SGCN for the Northern Lake Michigan Coastal Ecological Landscape (see Appendix 15.E for a complete list of SGCN occurring in this ecological landscape and the habitats with which they are associated).

Door Peninsula wetlands provide habitat for the U.S. Endangered Hine's emerald dragonfly, a globally rare species. Photo by Kathryn Kirk.

*Dorcas copper (*Lycaena dorcas*) (Wisconsin Special Concern) nectaring on shrubby cinquefoil. Photo by Kyle Johnson.*

Categories of Significant Wildlife

- **Rare species** are those that appear on the Wisconsin DNR's Natural Heritage Working List as Wisconsin or U.S. Endangered, Threatened, or Special Concern.
- **Species of Greatest Conservation Need** are described and listed in the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b) as those native wildlife species that have low or declining populations, are "indicative of the diversity and health of wildlife" of the state, and need proactive attention in order to avoid additional formal protection.
- **Responsibility species** are both common and rare species whose populations are dependent on Wisconsin for their continued existence (e.g., a relatively high percentage of the global population occurs in Wisconsin). For such a species to be included in a particular ecological landscape, a relatively high percentage of the state population needs to occur there, or good opportunities for effective population protection and habitat management for that species occur in the ecological landscape. Also included here are species for which an ecological landscape holds the state's largest populations, which may be critical for that species' continued existence in Wisconsin even though Wisconsin may not be important for its global survival.
- **Socially important species** are those that provide important recreational, social, or economic benefits to the state for activities such as fishing, hunting, trapping, and wildlife watching.

The American White Pelican is a spectacular bird that now occurs occasionally in and around the Door Peninsula and Green Bay. Photo by Herbert Lange.

Responsibility Species. This ecological landscape provides a rich diversity of habitats for a variety of fauna. The Hine's emerald, a globally rare, U.S. Endangered dragonfly, occurs in the coastal ridge-and-swale habitats. The Ridges Sanctuary in northeastern Door County has the world's largest documented population. The only other known populations are in Wisconsin's Southeast Glacial Plains and Western Coulees and Ridges ecological landscapes, in northern Michigan, northeastern Illinois, and in Missouri. Some other sites known to support the Hine's emerald in Wisconsin include Big Marsh on Washington Island and Three-Springs Creek, Mud Lake Wildlife Area, and Piel Creek on the Door Peninsula. The Hine's emerald uses calcium-rich wetlands, and the larvae use crayfish burrows to overwinter and to survive periods of low water. The wetlands the larvae inhabit tend to exhibit dramatic annual wet and dry cycles, which appear to create conditions that favor their survival. Other rare insects occurring on the Door Peninsula include at least two that are Wisconsin Endangered, the Lake Huron locust and swamp metalmark butterfly.

Globally rare land snails such as the Wisconsin Endangered Midwest Pleistocene vertigo and six-whorl vertigo (*Vertigo morsei*) are found on the Niagara Escarpment. Other rare snails associated with the Niagara Escarpment include the Wisconsin Threatened cherrystone drop and the Wisconsin Special Concern mystery vertigo (*V. paradoxa*), dentate supercoil (*Paravitrea multidentata*), and black striate (*Striatura ferrea*).

Historically, the U.S. Endangered Piping Plover nested in this ecological landscape. There was a record of a nesting Piping Plover at Seagull Bar State Natural Area at the mouth of the Menominee River in Marinette in 2001, but that nest failed, apparently due to mammalian predation. Piping Plovers have not returned to this site since then. This was the first nesting record in 50 years for Piping Plovers along the Lake Michigan shore in Wisconsin.

Rare waterbirds such as the Wisconsin Threatened Great Egret and the Wisconsin Endangered Caspian Tern and Common Tern nest along the Lake Michigan and Green Bay shorelines and on islands. Uncommon waterfowl with

limited distribution in the state such as Red-breasted Merganser (*Mergus serrator*), Common Merganser (*Mergus merganser*), and Common Goldeneye (*Bucephala clangula*) nest here. Lake Michigan provides important wintering habitat for species such as Greater Scaup (*Aythya marila*), Common Goldeneye, Common and Red-breasted Mergansers, Black Scoter (*Melanitta americana*), Surf Scoter (*M. perspicillata*), White-winged Scoter (*M. fusca*), and Long-tailed Duck (*Clangula hyemalis*). The Lake Michigan shoreline is an important migratory corridor for many birds, including hawks, waterfowl, and passerines.

The Wisconsin Threatened Yellow Rail has been documented during the breeding season in the extensive sedge meadows of the Mink River Estuary near Rowley's Bay, Door County. The Wisconsin Endangered Forster's Tern has nested along the west shore of Green Bay. For a short period of time, Oconto Marsh—at the mouth of the Oconto River—had Wisconsin's only nesting Snowy Egrets (*Egretta thula*).

The lower Wolf River and its major tributaries provide highly significant spawning habitat for the lake sturgeon. This basin supports the largest self-sustaining lake sturgeon population in North America. Traditional spawning areas were natural in-stream riffles and rocky areas along banks. Natural changes in the river's path, along with increased shoreline development, caused more fine sediment to be transported downstream, covering some spawning areas with silt. The addition of rock rip-rap to protect shorelines from erosion has sometimes had the unanticipated benefit of providing additional spawning areas for lake sturgeon (Wisconsin DNR 2001b). While riprapping has had some benefits for lake sturgeon, there is concern that excessive riprapping may interfere with the natural dynamics of the river, such as channel meandering, and degrade habitats for other fish, some of which also merit conservation attention.

Significant Wildlife in the Northern Lake Michigan Coastal Ecological Landscape

- Colonial water birds; migratory, nesting, and wintering birds; and spawning fish that use Lake Michigan, its estuaries, reefs, marshes, islands, and shoreline complexes.
- Globally rare invertebrates occurring in alkaline wetlands and beach and dune habitats on the east side of the Door Peninsula.
- Rare land snails inhabiting the Niagara Escarpment.
- Open water, wetland, and forest wildlife along the west shore of Green Bay's extensive marshes, sedge meadows, shrub swamps, and hardwood swamps.
- Lowland forest wildlife utilizing the extensive cedar, tamarack, and black ash swamps north and east of Lake Noquebay.
- Many northern forest birds and other species found in the forested uplands.
- Fish and other wildlife using warmwater rivers and streams entering Lake Michigan and Green Bay, including a biologically rich stretch of the lower Wolf River.
- Declining grassland birds occurring at some agricultural sites near Lake Michigan.

Socially Important Fauna. A commercial fishery for lake whitefish, yellow perch, rainbow smelt (*Osmerus mordax*) and ciscoes occurs on Lake Michigan and is very important to the region's economy. Recreational fishing on Lake Michigan and Green Bay is also very important, especially for yellow perch, walleye, northern pike, smallmouth bass, and introduced nonnative salmonids, including rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), Chinook salmon (*Oncorhynchus tschawytscha*), and coho salmon (*Oncorhynchus kisutch*). A major effort has been made recently to reestablish the Great Lakes form of muskellunge (*Esox masquinongy*) in the Green Bay ecosystem. It remains to be seen whether this fishery will become self-sustaining, but many large stocked fish are present, and it has become extremely popular with anglers in the last five years. Warmwater streams and rivers emptying into Green Bay support walleye, bluegill (*Lepomis macrochirus*), yellow perch, and other panfish populations sought by anglers. Waterfowl, especially diving ducks, and white-tailed deer are important for hunting. Many species of birds, such as gulls, terns, and other waterbirds, are important for wildlife viewing in this ecological landscape. This ecological landscape is important for bird watching, particularly during spring and fall migrations.

Double-crested Cormorants (*Phalacrocorax auritus*) have become abundant in recent decades, causing damage to island vegetation, and are viewed by some commercial and recreational anglers as nuisance predators on fish populations in Green Bay. However, the yellow perch population rebounded in lower Green Bay in 2003, while the local breeding cormorant population had remained stable at approximately 2,000 breeding pairs for seven years, suggesting that cormorants were not the primary factor limiting the yellow perch population (see Chapter 8, "Central Lake Michigan Coastal Ecological Landscape," for more details on this issue). Herring Gulls (*Larus argentatus*) and Ring-billed Gulls (*Larus delawarensis*) are also now very numerous and can be a nuisance by concentrating in areas to feed on garbage and by displacing other colonial nesting birds. Effects on the vegetation of some nesting islands in the Grand Traverse archipelago have been devastating (Judziewicz 2001).

Wildlife Habitats and Communities. This ecological landscape supports many important wildlife species associated with Lake Michigan and its shorelines, the Niagara Escarpment,

Green Bay's west shore marshes, the Wolf River corridor, scattered cedar, tamarack, and ash swamps, and warmwater rivers and streams. Six Important Bird Areas have been designated within or partially within the Northern Lake Michigan Coastal Ecological Landscape (Steele 2007) (see the map entitled "Ecologically Significant Places of the Northern Lake Michigan Coastal Ecological Landscape" in Appendix 15.K).

The Lake Michigan and Green Bay shorelines, islands, and adjacent waters provide important nesting and feeding habitats for many fish-eating colonial nesting birds, including Caspian Tern, Common Tern, American White Pelican (*Pelecanus erythrorhynchos*), Double-crested Cormorant, Great Blue Heron (*Ardea herodias*), and Black-crowned Night-Heron (*Nycticorax nycticorax*). The Great Lakes shorelines are also important to Herring and Ring-billed Gulls, which nest in large colonies there. Small numbers of the Great Black-backed Gull (*Larus marinus*) have nested along the Great Lakes shores in recent years. Other waterfowl that nest along the Lake Michigan shores include Red-breasted and Common Mergansers and Common Goldeneye.

The Lake Michigan shoreline on both sides of the Door Peninsula and the west shore of Green Bay are important migratory corridors for many birds, including hawks, waterbirds, and passerines. Raptors and passerines use the shoreline as a landmark and as feeding and resting places during migration. Waterfowl use the waters along the Lake Michigan shoreline during migration and as wintering habitat, including some species with limited distribution within the state such as Greater Scaup, Common Goldeneye, Common and Red-breasted Mergansers, Long-tailed Duck, and Black, Surf, and White-winged Scoters. Recent surveys of open water habitats in Lake Michigan have revealed that tens of thousands of diving ducks and other waterbirds are using offshore habitats (Figure 15.7), some of them as many as 10 miles from shore (Mueller et al. 2010). Three waterfowl species composed over 87% of the total waterfowl seen during the fall, winter, and spring surveys of 2010–2011: Long-tailed Duck (47.6%), Red-breasted Merganser (29.9%), and Common Goldeneye (9.6%). The Red-breasted Merganser was found throughout all seasons and was distributed all along the west coast of Lake Michigan. The Long-tailed duck was found mostly in the fall and along the northern Lake Michigan coast in this ecological landscape. A total of 25,555 Long-tailed Ducks were seen on one day (2 November 2010).

The large, undeveloped ridge-and-swale complexes on the east side of the Door Peninsula support breeding populations of many sensitive birds, including neotropical migrants such as the Northern Waterthrush (*Parkesia noveboracensis*), Canada Warbler (*Cardellina canadensis* but listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List), and Golden-winged Warbler (*Vermivora chrysoptera*) as well as Northern Goshawk (*Accipiter gentilis*), Merlin (*Falco columbarius*), and other rarities. This natural community also provides habitat for rare invertebrates such as the Hine's emerald dragonfly (see "Responsibility Species" above).

The Niagara Escarpment is a prominent Door Peninsula geological feature, which provides an important migration corridor for birds and is habitat for many rare terrestrial snails, including globally rare species (see "Responsibility Species" above).

Surrogate Grasslands, especially hayfields and lightly grazed pastures near Lake Michigan, provide nesting habitat for sensitive grassland birds such as Upland Sandpiper, Bobolink (*Dolichonyx oryzivorus*), and Eastern Meadowlark (*Sturnella magna*). Delayed harvest because of the cooling influence of Lake Michigan allows some birds to fledge broods with greater success than they do farther inland. However, care needs to be taken to avoid conflicts with management and restoration of coastal forests, which would generally be a higher priority here (Sample and Mossman 1997).

The extensive marshes on the west shore of Green Bay are very important to waterfowl and other marsh birds, including Yellow Rail, Forster's Tern, and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). Over 250 bird species have been recorded there, including colonial waterbirds and rare marsh birds, and this wetland complex continues to receive heavy use as a resting, feeding, and staging area

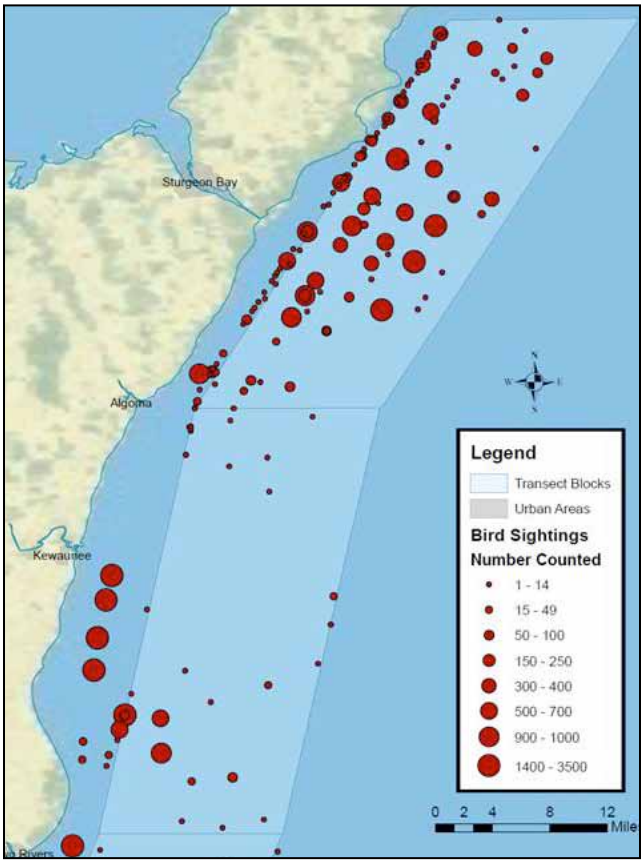


Figure 15.7. *Concentration of waterfowl and waterbirds along the northern Lake Michigan coast during fall and winter 2010–11. Figure provided by William Mueller of Western Great Lakes Bird and Bat Observatory and Ginny Plumeau, Amy Wagnitz, and Cindy Burtley of Cedarburg Science LLC (BHE Environmental).*

Extensive Northern Sedge Meadow and conifer swamp. North Bay, on the northeastern Door Peninsula. Photo by Eric Epstein, Wisconsin DNR.

Unvegetated exposure of sand and mud at the tip of Seagull Bar, Marinette County. Such sites are of high value to shorebirds and other fauna. Photo by Emmet Judziewicz.

during migration. Oconto Marsh and other coastal wetlands nearby supported many nesting marsh birds, including Great Blue Heron, Black-crowned Night-Heron, and Great Egret, prior to the invasion of common reed. Black-crowned Night-Heron also nested on Green Island (a remote island halfway between the west shore of Green Bay and the Door Peninsula). Seagull Bar, Peshtigo Point, Charles Pond, Little Tail Point, and Long Tail Point provide habitat for large numbers of migrating birds, especially waterfowl, shorebirds, gulls, terns, and herons. However, the simplification of marsh composition due to the invasion of exotic plants has reduced habitat diversity in many areas, thus reducing the numbers and species of birds using the area for breeding and foraging (Steele 2007). These marshes are also valuable spawning areas for fish such as northern pike.

Forested wetlands east and north of Lake Noquebay (especially of conifers such as northern white-cedar and tamarack) are important breeding areas for species such as Winter Wren (*Troglodytes hiemalis*), Nashville Warbler (*Oreothlypis ruficapilla*), White-throated Sparrow (*Zonotrichia albicollis*), Red-breasted Nuthatch (*Sitta canadensis*), Golden-crowned Kinglet (*Regulus satrapa*), and Northern Waterthrush. Where conditions are boggy, the habitat becomes important for mink frogs (*Lithobates septentrionalis*). The corridor of the lower Peshtigo River supports one of Wisconsin's more northerly forested floodplain systems and has supported nesting Red-shoulder Hawks plus "southern" birds such as Cerulean Warblers (*Setophaga cerulea* but listed as *Dendroica cerulea* on the the Natural Heritage Working List) and Blue-gray Gnatcatchers (*Polioptila caerulea*). Other species that benefit from forested floodplain habitat here include Yellow-billed Cuckoo (*Coccyzus americanus*) and eastern red bat (*Lasiurus borealis*).

The biological community of Lake Michigan, including its fish community, has undergone significant changes. Some of the reasons for these changes are habitat degradation, the overharvest of some species, and the introduction of invasive species and other nonnative species. At least five native fish species endemic to the Great Lakes (depending on the taxonomy followed) have been functionally extirpated (remaining populations are not expected to survive) or have been determined to be extinct. These species include four coldwater ciscoes: shortnose cisco (*Coregonus reighardi*), kiyi (*Coregonus kiyi*), shortjaw cisco (*Coregonus zenithicus*), and deepwater cisco (*Coregonus johannae*) (Eshenroder et al. 1995, J. Lyons, Wisconsin DNR, personal communication).

Shortnose and deepwater ciscoes are extinct. The kiyi and shortjaw cisco remain in Lake Superior. Unfortunately, given the highly modified habitat and biological community in much of Lake Michigan, it is unlikely that any of these surviving coldwater cisco species could be restored here without major environmental improvements in the lake. The cisco, or "lake herring," has become quite rare and is functionally gone from Lake Michigan, although on occasion someone catches one. The lake herring remains in Lake Superior. Paddlefish (*Polyodon spathula*) are extirpated from Lake Michigan but remain in the Mississippi River basin. Spoonhead sculpin (*Cottus ricei*) has functionally disappeared from Lake Michigan, although a few are encountered in the northern part of the lake. They are still found in Lake Superior. The banded killifish (*Fundulus diaphanus*) (Wisconsin Special Concern) occurs in Lake Michigan and Green Bay at various places along the Door Peninsula.

A thriving and economically important lake trout population was extirpated by the early 1950s due to factors that included overfishing, habitat degradation, alewife (*Alosa pseudoharengus*) and rainbow smelt invasion, and heavy losses from the parasitic, nonnative invasive sea lamprey. These nonnative species entered the Great Lakes via constructed shipping canals farther east (e.g., bypassing Niagara Falls). Although tremendous numbers of trout have been stocked in the lake, and sea lamprey control efforts have kept this parasite largely in check, lake trout have not been reproducing or reaching maturity with success. A lake

trout restoration plan is in place for Lake Michigan. While it relies heavily on stocking diverse strains of lake trout in deep, remote and protected mid-lake reefs, there are several recovery sites in Lake Michigan's near-shore waters off Door County (Bronte et al. 2008).

The Lake Michigan stocking program of introduced nonnative salmonids (rainbow trout, brown trout, Chinook salmon, and coho salmon) has established a sport fishery in these waters and put predation pressure on the exotic alewife. Lake Michigan and Green Bay shorelines and wetlands are important spawning areas for smallmouth bass, northern pike, and other game and forage fish. The waters of Lake Michigan and Green Bay are important habitat for yellow perch, walleye, northern pike, smallmouth bass, and the aforementioned exotic salmonids.

The reefs off of the northeastern shore of the Door Peninsula are the only spawning areas in the Wisconsin waters of Lake Michigan for lake whitefish, an important commercial fish species. Lake whitefish spawn predominantly in the areas off North Bay and Moonlight Bay in Door County. However, some spawning apparently takes place from the northern tip of the Door Peninsula almost all the way south to Whitefish Point, south of Whitefish Dunes State Park. Fish managers suspect that whitefish also spawn in some areas of Green Bay. Whitefish fry move inshore with currents and use the bays and nearshore areas all along the east shore of the Door Peninsula as a nursery. Whitefish movement and distribution has changed over the past 20 to 30 years, apparently in response to pressures from invasive species. Whereas most juveniles used to remain off spawning grounds along the west shore of Lake Michigan, they are moving much more and are now often found in Green Bay and are suspected to use other sites that have not yet been discovered (Hanson 2009).

The Menominee, Peshtigo, and Oconto rivers are the three largest rivers entering Green Bay in the Northern Lake Michigan Coastal Ecological Landscape. The Pensaukee, Suamico, and Little Suamico rivers are smaller but also flow into Green Bay. These rivers and streams are important spawning areas for many fish species, including northern pike and walleye. Introduced (but nonreproducing) salmonids offer seasonal angling opportunities during spawning runs. The Menominee and Peshtigo rivers also provide habitat for lake sturgeon. Other warmwater rivers and streams support rare species such as the Wisconsin Endangered snuffbox mussel. Adults of rare dragonflies such as the swamp darner (*Epiaeschna heros*) and arrowhead spiketail (*Cordulegaster obliqua*) have been found along such streams and their associated wetlands.

The lower Wolf River (below the Shawano Dam) has many Species of Greatest Conservation Need, including lake sturgeon (see "Responsibility Species" above), greater redhorse, river redhorse, shoal chub, western sand darter (*Ammocrypta clara*), four-toed salamander (*Hemidactylium scutatum*), wood turtle, Blue-winged Teal (*Anas discors*), and Great Egret. The Shawano Dam blocks the upstream movement of fish species, including the historical upstream spring spawning run of the lake sturgeon. Mussel diversity in the reach below the Shawano Dam remains very high. Rare mussels such as the elktoe (*Alasmidonta marginata*), round pigtoe (*Pleurobema sintoxia*), and snuffbox occur here. Other invertebrates, including elegant spreadwing damselfly (*Lestes inaequalis*), elusive clubtail dragonfly (*Stylurus notatus*), pygmy snaketail dragonfly, stygian shadowfly (*Neurocordulia yamaskanensis*), Caenid mayfly (*Brachycercus prudens*), and White River crayfish (*Procambarus acutus*) have been found here. These species are generally indicators of healthy, diverse habitat and very good water quality, and some are listed as Species of Greatest Conservation Need. The Little Wolf River is a smaller stream with a clean gravel substrate and good invertebrate diversity, including populations of the Wisconsin Threatened pygmy snaketail dragonfly.

The Red River, in Shawano County from below Gresham to the Wolf River, has not been systematically surveyed, but based on habitat characteristics and its connection to the biologically rich Wolf River, it has the potential to support a diverse native aquatic fauna, and merits additional biological survey attention (B. Smith, Wisconsin DNR, personal communication). Although inland lakes are uncommon in this ecological landscape, Lake Mary, along upper Inlet Creek upstream of Lake Noquebay in Marinette County, supports one of only five Wisconsin populations of the rare slaty skimmer dragonfly.

Natural and Human Disturbances

Fire, Wind, and Flooding

On the Door Peninsula and in the Grand Traverse Islands, fire was likely a minor historical disturbance. In the western part of the Northern Lake Coastal Ecological Landscape, adjacent to the more fire prone areas of the Northeast Sands, fire may have once played a much larger disturbance role. Soil types and most of the forest vegetation on the Door Peninsula are more mesic, suggesting that fires were relatively infrequent there.

However, the catastrophic Peshtigo fire in northeastern Wisconsin burned an area approximately twice the size of Rhode Island, about 1.2 million acres of land (Figure 15.8). Land-clearing and logging practices of the time had left behind many thousands of acres of dry woody debris. A record drought during the spring and summer of 1871 gave rise to an intense fire season in northern forests, culminating on the night of October 8, 1871, when a cold front with strong winds whipped up many smaller fires into a massive conflagration. Twelve towns were destroyed, and between 1,200 and 2,500 people died, with the greatest loss of life occurring in the village of Peshtigo. The fire jumped several miles over the waters of Green Bay and also burned parts of the Door Peninsula. The fire was so intense that it vaporized the soil in places (Gess and Lutz 2002), undoubtedly affecting what vegetation was able to grow after the fire.

Windthrow was a natural disturbance that historically occurred frequently in this ecological landscape. Storm events

most often resulted in many small windfall gaps (Frelich and Lorimer 1991), but some large-scale catastrophic windthrow events occurred. These catastrophic wind events can result directly in forest stand replacement and provide downed and dead trees and other debris as fuel for fires. Because intervals between severe wind events were longer than the maximum age of shade tolerant trees, Frelich and Lorimer (1991) suggested that wind-prone landscapes were dominated by mature to old-age forests. Light to moderate levels of windthrow likely facilitated or maintained dominance of hemlock, which was multi-aged, while heavy windthrow may have favored hardwoods (Schulte and Mladenoff 2005). Yellow birch, which is less shade tolerant than hemlock, may have been dependent on heavy windthrow disturbance (see the "Wind Disturbance" section of Chapter 12, "North Central Forest Ecological Landscape," for more details on this topic).

Natural disturbance regimes have been altered by human activities. Wind disturbance in the mesic and wet portions of the ecological landscape is likely reduced from historical conditions because forests are generally younger and less subject to being windthrown (there is also far less mesic forest now than there was historically). As a result, canopy gaps and associated features such as ***tip-up mounds*** and dense thickets of saplings or shrubs are now scarcer, and their absence can negatively impact species requiring these structural features (e.g., certain birds and herptiles).

The extent and frequency of flood disturbance prior to Euro-American settlement is unknown. Natural changes in Lake Michigan water levels have significant effects on the extent and sometimes on the composition of coastal vegetation and on navigation. Short-term seiches can alter water levels by a few inches to several feet. The rapidly rising water levels caused by seiches can inundate coastal wetlands. Longer-term water level changes, due to drought or extended wet periods, can also impact coastal wetland vegetation. During periods of low water, coastal marshes and sedge meadows

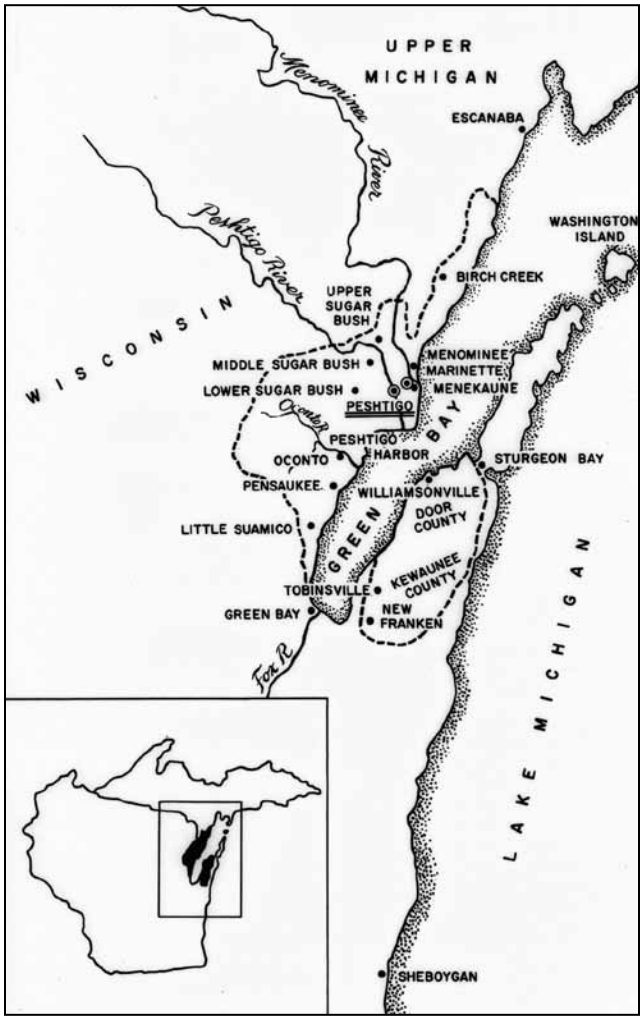
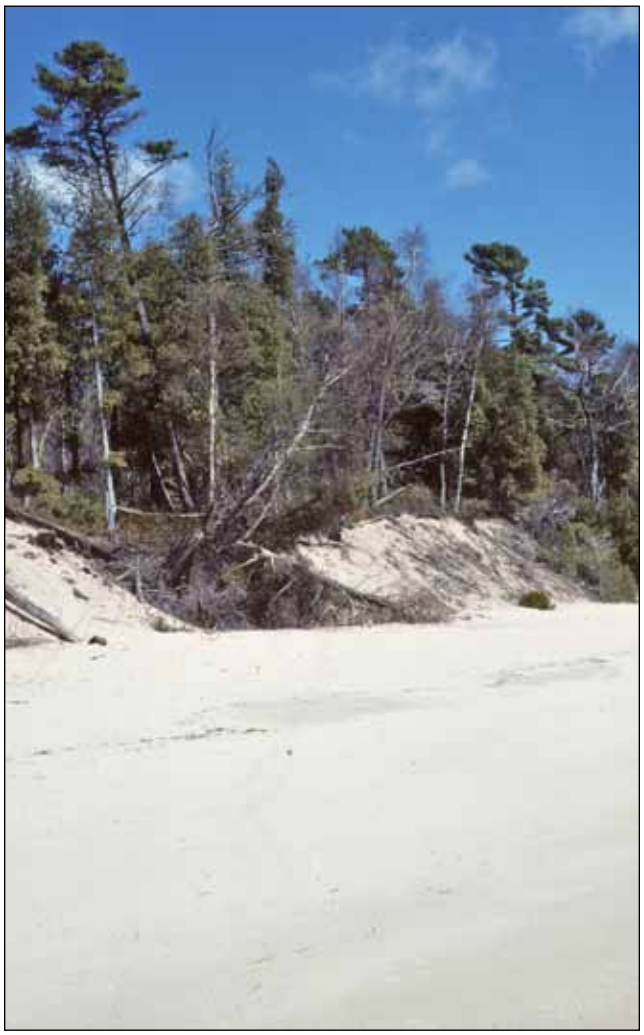


Figure 15.8. *The outlined areas on the map show the extent of the most severely burned locations along Green Bay (1,280,000 acres) in the 1871 Peshtigo fire. Map courtesy of the Wisconsin Historical Society, Image WHi-3844.*

Gap due to windthrow in shoreline forest near Lake Michigan is filling with sapling eastern hemlock and northern white-cedar. Excessive browse pressure from white-tailed deer has greatly curtailed reproduction by both of these important tree species across most of Wisconsin. Mike Grimm, Sturgeon Bay Office of The Nature Conservancy. Photo by Eric Epstein, Wisconsin DNR.

can become drier, sometimes allowing woody vegetation to become established. During periods of high water, coastal wetlands are flooded and may be reduced in extent. Global climate change could have a major influence on Great Lakes water levels and the extent of coastal wetlands. When Great Lakes water levels are high and strong seiches and storms occur, shorelines erode and the amount of shoreline vegetation is reduced. The hydrology of Green Bay is especially dynamic. At some levels, these fluctuations are necessary to maintain the amount and the mosaic of associated wetland vegetation. However, in recent decades, altered runoff patterns, excess nutrients and sediments, the extensive loss of wetlands during drier periods, and the appearance of many invasive species have caused dramatic disruptions of these ecosystems. It seems unlikely that they will return to their previous states, at least not anytime soon, as some of these changes are "permanent," and unforeseen new factors that trigger change will be occurring in the future.



Great Lakes Beach and partially forested foredune. Erosion occurred when Lake Michigan water levels were high. Whitefish Dunes State Park, Door County. Photo by Eric Epstein, Wisconsin DNR.

Forest Insects and Diseases

The Northern Lake Michigan Coastal Ecological Landscape is a heterogeneous area due to the diverse elements of the physical environment caused by the last glaciation and the influence of Lake Michigan. It supports a number of forest types, each of them associated with different insects and diseases that can periodically affect forest vegetation in this ecological landscape.

Aspens can be impacted by forest tent caterpillar (*Malacosoma disstria*), aspen heart rot fungus (*Phellinus tremulae*), and aspen hypoxylon canker fungus (*Hypoxylon mammatum*). White birch can be affected by bronze birch borer (*Agrilus anxius*), and drought can predispose these trees to many diseases. Conifers, including red pine (*Pinus resinosa*), eastern white pine, and white spruce, can be affected by Annosum root rot, caused by the fungus *Heterobasidion annosum*, particularly in plantations. Red pines are also subject to "***pocket mortality***," caused by a complex of insects and the pocket mortality fungal species *Leptographium terrebrantis* and *L. procerum*. Red pine is also susceptible to Diplodia pine blight fungus (*Diplodia pinea*) and pine sawfly (*Neodiprion* spp., *Diprion* spp.). White pine blister rust is an introduced fungal disease caused by *Cronartium ribicola*; it is most severe in low-lying areas.

Dutch elm disease is caused by the fungus *Ophiostoma ulmi*, which is transmitted by two species of bark beetles or by root grafting. American elm (*Ulmus americana*) is more seriously affected than other elm species, but all of our native elm species are somewhat susceptible, as is the nonnative Siberian elm (*Ulmus pumila*). American elm has essentially been eliminated as a component of the forest overstory but is still a significant part of the understory and seedling layers. Its life span is typically now about 30 years before it succumbs to Dutch elm disease. The loss of American elm as a supercanopy or dominant tree has impacts on associated wildlife species, such as Wood Duck (*Aix sponsa*).

Gypsy moth (*Lymantria dispar*) is a nonnative insect that is currently becoming established in this ecological landscape and will periodically affect oak and aspen forests. The two-lined chestnut borer (A*grilus bilineatus*) is a bark-boring insect that attacks oaks. Oak wilt is a vascular disease caused by the native fungus *Ceratocystis fagacearum*.

The emerald ash borer (*Agrilus planipennis*) is an exotic insect native to Asia. This extremely serious forest pest was discovered near the Milwaukee River in Ozaukee County, Washington County, and in Brown County, just to the south, in the Central Lake Michigan Coastal Ecological Landscape. Brown, Crawford, Dane, Dodge, Douglas, Fond du Lac, Kenosha, La Crosse, Milwaukee, Ozaukee, Racine, Rock, Sauk, Trempealeau, Vernon, Walworth, Washington, Waukesha, and Winnebago counties have been placed under quarantine in an effort to help prevent the human aided spread of the emerald ash borer. Sheboygan and Jefferson counties are also under quarantine because of their proximity to infestations in neighboring counties. The purpose of the quarantine

is to limit the artificial spread of the emerald ash borer, which may be present in ash nursery stock, hardwood firewood, timber, or other articles that could spread emerald ash borer into other areas of Wisconsin or other states.

Attempts to contain infestations in Michigan through destroying ash trees in areas where emerald ash borer was found have not been successful, perhaps because the insect was well established before it was noted and identified. The emerald ash borer typically kills a tree within one to three years. Emerald ash borer has also been shown to feed on some shrub species (e.g., privets, lilac) in greenhouse tests, but it is unknown as to whether shrub availability will contribute to its spread under field conditions. The emerald ash borer could have an impact on forest composition and structure here, especially in the ash swamps west of Green Bay, and perhaps in the forested floodplain along the Wolf River. Scattered concentrations of ash also occur at a few other locations. Consult the Wisconsin emerald ash borer website (Wisconsin DATCP et al. 2013) for the most up-to-date information about the emerald ash borer in Wisconsin.

Beech bark disease is a major threat to American beech in eastern North America and in this ecological landscape. The disease is the result of an interaction between a beech scale insect (*Cryptococcus fagisuga*) and one of several species of fungi, and the disease does not occur if either is absent. One beech bark disease fungus (*Nectria galligena*) is a native North American fungus, and the other common fungus is an introduced fungus (*Nectria coccinea* var. *faginata*). Beech scale insects were accidentally introduced from Europe into Nova Scotia, Canada, around 1890. By the 1930s, the scale and an associated *Nectria* fungus were found to be killing trees in eastern Canada and Maine. The disease has continued to spread and was discovered in Door County in September 2009. Because the disease requires both the insect and fungus, killing the scales will prevent the disease from occurring. However, this is impractical at a large scale. A small percentage of trees are resistant to the scale and do not develop disease symptoms even in heavily infected stands. Therefore, breeding resistant trees is a possible long-term management option. Management options depend on whether the infestation is small and isolated or widespread. Currently, there are no special recommendations for managing beech bark disease in preparation for the spread of beech bark disease in Wisconsin. However, when a stand is marked for thinning during the next regularly-scheduled entry, consideration should be given to removing beech trees with low vigor and/or rough bark. Vigorous beech trees with smooth bark should be retained, and stands should be kept adequately stocked. Management guidelines may change over time due to changing disease distribution and new research findings.

More information about these diseases and insect pests of forest trees can be found at the Wisconsin DNR's forest health web page (Wisconsin DNR 2013a) and at the U.S. Forest Service Northeastern Area forest health and economics web page (USFS 2013).

Invasive Species

Due in part to the high levels of development and disturbance, the large number of travelers, and the frequent and varied recreational use of this ecological landscape, many nonnative invasive species have become problems. This ecological landscape is relatively vulnerable to additional invasions and as a source from which some invasive species may spread. Better methods are needed to prevent the spread and introduction of additional invasive species.

Terrestrial invasive species are common in the ecological landscape. In forested communities, garlic mustard (*Alliaria petiolata*), glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), nonnative honeysuckles (including *Lonicera tatarica, L. morrowi*, and several other *Lonicera* species), and dame's rocket (*Hesperis matronalis*) already pose problems. These species may initially colonize disturbed areas and edges, but once established spread to surrounding areas, including forest interior. The invasion of forests by European earthworms of the family Lumbricidae is a concern in this ecological landscape (see the "Invasive Species" section in Chapter 12, "North Central Forest Ecological Landscape," for more details on the effects of earthworms).

Invasive plants of open areas may occur along roads and other rights-of-way, in disturbed open or partially forested areas, and on dunes and upper beaches. Problem species in such habitats include spotted knapweed (*Centaurea biebersteinii*) and leafy spurge (*Euphorbia esula*). Lyme grass (*Leymus arenarius*) is a serious problem in some Great Lakes dune and beach habitats and has been collected from multiple sites on the Lake Michigan shore of Door County.

In aquatic and wetland ecosystems, common reed, narrow-leaved and hybrid cat-tails, purple loosestrife, reed canary grass, European swamp thistle (*Cirsium palustre*), Eurasian water-milfoil, and rusty crayfish (*Orconectes rusticus*) are among the primary problem species. Round goby (*Neogobius melanostomus*), zebra mussel (*Dreissena polymorpha*), quagga mussel (*D. bugensis*), spiny water flea (*Bythotrephes cederstro-*

Pond, sedge meadow, and fen. The tall grass is common reed, a serious invasive plant. Coffey Swamp, Washington Island, Door County, early 1970s. Photo by William Tans.

emi), white perch (*Morone americana*), sea lamprey, alewife, and rainbow smelt are important invasives in Lake Michigan and Green Bay. There is concern that some of these invasives may reach inland waters, but it has not happened yet. There are common carp (*Cyprinus carpio*) in Green Bay as well as in the lower Wolf River system and the lower stretches of the Oconto, Peshtigo, and Pensaukee rivers.

In recent decades, there has been a radical, possibly irreversible, shift in the species composition of many of the marshes and sedge meadows bordering the west shore of Green Bay. This was apparently triggered by the response of invasive plants to dramatic water level changes in the Bay (Meeker and Fewless 2008). (See the "Changes in Hydrology" section below.) The invasive common reed and narrow-leaved cat-tail became the overwhelmingly dominant species in the west shore marshes in lower Green Bay during 1997 to 2001, crowding out native plants (Frieswyk and Zedler 2007). Conditions in the Northern Lake Michigan Coastal Ecological Landscape with respect to these invasives may not be as severe at this time as they are in the marshes to the south at the head of the Bay in the Central Lake Michigan Coastal Ecological Landscape, but this may be a temporary condition that should be monitored closely and frequently. Prior to that time, purple loosestrife was considered to be the most serious of the invasive plants in the west shore wetlands in Green Bay along with reed canary grass. A cooperative effort between the Wisconsin DNR and the U.S. Fish and Wildlife Service is underway to try to control these invasive species across roughly 600 acres in several areas of southern Green Bay. Herbicide application has been followed with mowing and prescribed burning. This treatment has resulted initially in the reestablishment of native wetland species. However, control is not 100% effective, and without ongoing control work, treated areas are slowly shifting back to a *Phragmites*-dominated plant community.

In recent years, massive blooms of native filamentous green algae in the genus *Cladophora* have occurred. Similar blooms occurred in the 1960s and 1970s, then declined or disappeared during the 1980s and 1990s but have recently proliferated. Likely causal factors of past blooms included excessive nutrient inputs, especially of phosphorus. More recently, it is thought that the consumption of plankton by the now hyper-abundant exotic zebra and quagga mussels, has facilitated algae growth increasing water clarity, which allows for greater light penetration, stimulating algae growth to greater depths. Declining lake levels and changing lake currents (GLWI 2005) have also been implicated. When these algae, which have been recorded growing to depths of 30 feet, are deposited along the shores by wind, wave action, or currents, they decompose and create a stench that permeates the atmosphere for miles. Thus far, this problem has been termed as primarily a "nuisance," with no direct adverse health impacts. However, in an area that is so economically reliant on tourism, the negative impact could be highly significant.

For more information about invasive species in Wisconsin, see the Wisconsin DNR's web page on invasive species (Wisconsin DNR 2012b).

Land Use Impacts

Historical Impacts. Early Euro-American settlements sprang up along the shores of Lake Michigan and Green Bay where major rivers provided natural harbors for transporting goods and passengers. Early Euro-Americans found a landscape dominated by vast stands of American beech, eastern hemlock, maples, and American basswood around large conifer swamps and wetlands. Sawmills sprang up as the logging industry flourished. Commercial fishing and shipbuilding soon followed. Ample supplies of hemlock provided the tannins necessary for the tanning industry, which was first located on the shores of Lake Michigan (Wisconsin DNR 2001a). As land was cleared, agricultural uses expanded and continue to be the dominant land use today. Recreation and tourism have always been important in this ecological landscape, and much infrastructure has been developed to accommodate it.

The ecological impacts of large-scale logging and changing land uses in the latter half of the 19th century were immense in northern Wisconsin, including the Northern Lake Michigan Coastal Ecological Landscape (see the "Historical Impacts" section in Chapter 12, "North Central Forest Ecological Landscape," for more details). After extensive logging had occurred, this area attracted settlers, and activities such as agriculture, recreation, and commercial fishing began. There has been some regeneration of the forests, but they are now composed of different species, age structures, and patch sizes from the "original" forests (Schulte et al. 2007).

Many of these past land use impacts have left changes that are still with us today. For example, due to past logging practices, there are now relatively few older forests, and large trees (and conifers in particular) are underrepresented (e.g., eastern hemlock, eastern white pine, and in some areas, components of white spruce, balsam fir, and northern white-cedar). Agriculture is now prevalent across much of the ecological landscape except in the northwest. Present land use has created a patchwork of farm fields and woodlots rather than a matrix of mixed hardwood-conifer forest. Dams built for hydropower have changed the character of many streams and rivers.

Current Impacts. Disturbances in the current landscape are largely due to human activities, including the long-term conversion of land to agricultural uses, roads, and buildings. Shorter-term disturbances result from logging and some recreational pursuits. Some effects are indirect, such as the high level of herbivory by white-tailed deer, which is largely the result of human activities that affect the size of deer populations. A major difference from historical disturbances is that today's disturbance impacts are multiple and pervasive, affecting most of the landscape almost constantly.

Coffey Swamp, severely overbrowsed by white-tailed deer. Washington Island, Door County. Photo by Emmet Judziewicz.

Shoreline bluffs with narrow strip of conifer forest, small patches of mesic hardwood forest on blufftop. Landscape interior is dominated by intensive agricultural use. Photo by Luke Wuest.

Agriculture. Over half of the area in this ecological landscape has been converted from forest to agricultural use, with dairy farming being the primary agricultural pursuit. On the Door Peninsula, where the climate is directly affected and moderated by Lake Michigan, there are many cherry and apple orchards. Land cover is now a patchwork of farm fields and woodlots. This results in a fragmented landscape, lacking large patches of forest interior habitat. This is good for some species, like white-tailed deer, but it does not provide habitat for rarer, area-sensitive forest species. Agricultural activity can result in soil erosion and lessened water quality, but today many farms use conservation practices that prevent soil erosion and loss. However, recently a "science advisory team," composed of UW-Green Bay faculty, Sea Grant staff, graduate students, and representatives of the Wisconsin DNR and The Nature Conservancy, identified nonpoint pollution as one of the major factors contributing to poor water quality in Green Bay (M. Grimm, The Nature Conservancy, personal communication).

Groundwater contamination due to manure runoff or the use of pesticides can be an issue in parts of this ecological landscape such as the Door Peninsula and Grand Traverse Islands because of the highly fractured bedrock that is often close to the surface that allows agricultural chemicals and other pollutants to quickly leach into the groundwater.

Forest Management. The dominant forest type in the Northern Lake Michigan Coastal Ecological Landscape is maple-beech-basswood, followed by swamp hardwoods, swamp conifer, and aspen/birch. Some remnant boreal forest occurs in a narrow strip along Lake Michigan on the northeastern Door Peninsula (see Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book for additional information on natural communities). Almost all of the forests here are second-growth, resulting from turn-of-the-century (or earlier) logging and/or associated fires (Wisconsin DNR 2001a).

Old-growth maple-beech and maple-basswood forests were abundant here historically but are now virtually absent. There is a need to better represent missing or seriously diminished forest successional and developmental stages to conserve the full spectrum of natural communities and associated compositional, structural, and functional attributes.

A focus on stand-level forest management has resulted in many small to medium-sized patches of similar species composition and age-class structure, while at the broader scale there has been loss of patch size and age-class diversity. While some larger forested blocks of 1,000 acres or more are located in this ecological landscape, much of the remaining forest occurs in much smaller blocks of 100 acres or less. The large amount of edge habitat now present throughout much of the Northern Lake Michigan Ecological Landscape has promoted habitat generalists at the expense of interior forest habitat specialists, especially those that are area or disturbance sensitive. Better representation of large patches, older forest, and certain dominant species (e.g., some of the upland and lowland conifers, American beech) is needed to accommodate the habitat needs of some of these more sensitive species.

Ecological simplification and homogenization are taking place, with sugar maple and red maple increasing at the expense of other tree species, especially conifers, but including certain hardwoods, such as beech and yellow birch. Some forest herbs (e.g., certain lilies, orchids, and insect-pollinated species) are decreasing in abundance, while generalists and nonnative species are increasing (Rooney et al. 2004, Schulte et al. 2007).

Development. Tourism has been important in the Northern Lake Michigan Coastal Ecological Landscape for many decades. Door County is a major vacation destination for people throughout the Midwest and is nationally recognized as a premier vacation destination (Wisconsin DNR 2001a). Year-round outdoor recreational opportunities and a wealth of scenic beauty and natural features make the Door County area a major attraction. Communities throughout

this ecological landscape recognize the tourism potential and capitalize on this opportunity with unique shops, maritime museums, historic villages, and waterfront and marina development. All of these tourism developments and heavy recreational use have had an impact on the ecological landscape, especially the Door Peninsula. Increased infrastructure and tourist facilities to accommodate large numbers of people have increased development in the area. Along with increased development are more impervious surfaces and greater runoff and degradation of water quality. More people in boats or other motorized vehicles have increased disturbance to aquatic life and degraded water quality. Heavy use of trails and beaches can be to the detriment of sensitive wildlife and plant species.

Recreational boating, including use of personal watercraft, is a popular activity in Wisconsin. Estimates indicate that one in ten Wisconsin residents owns a registered boat (Wisconsin DNR 2001a). Over the years, the growth in boating has been accompanied by an increase in average horsepower from less than 5 to more than 55 during the past 50 years. The downside of boating activity is that it causes environmental damage through uprooting of vegetation, resuspension of sediments, wave-induced shoreline erosion, and contamination of water from fuel and exhaust by-products such as hydrocarbons and trace metals. Boats can also spread invasive species like Eurasian water-milfoil and zebra mussels (Wisconsin DNR 2001a).

There have been increases in seasonal and permanent residents, both inland and, especially, along the lake and bay shores. This trend has led to high land prices and increased the pace and scale of development on shorelines (Wisconsin DNR 2001a). The development of a shoreline parcel adversely impacts adjacent aquatic habitat in a number of ways and the cumulative impacts of numerous such projects can be substantial. Replacing natural vegetation with lawns, buildings, and driveways can result in increased runoff of nutrients and sediments, negatively impacting water quality. Addition of fertilizers and pesticides adds to the water quality problem. Shoreline construction in the form of rock riprap or a seawall destroys the natural transition between upland and shore, can attract exotic species such as the round goby and zebra mussel, and can increase erosion along nearby unprotected beach habitats due to wave refraction (Wisconsin DNR 2001a). See the "Land Use Impacts" section in Chapter 14, "Northern Highland Ecological Landscape," for a more detailed discussion of the impacts of lakeshore development.

Parcelization and dispersed residential development in rural areas fragments formerly contiguous habitats, reduces their effective size, raises land values and taxes, increases the cost of public services, and creates long-term alterations in aquatic and terrestrial systems. Some of the ecological consequences of these human-influenced factors include increases in habitat generalists, nonnative species, and cultural habitats (e.g., roads, utility rights-of-way, lawns, landscaping, golf courses, sand blankets, sand and gravel quarries), disrupted hydrology, and predation or harassment of wildlife by free-ranging domestic dogs and cats. Shoreline structures such as piers, boat lifts, and ramps can reduce (and locally eliminate) the amount of nearshore submergent and emergent aquatic macrophytes habitats that benefit many aquatic organisms.

Residential development and construction of a golf course have fragmented forest habitat near Egg Harbor, Door County. Photo by Eric Epstein, Wisconsin DNR.

Changes in Hydrology. Development of land for agricultural, urban-industrial, or other purposes has resulted in the loss of a significant amount of historical wetland acres. This has contributed to decreased water quality, less flood mitigation potential, and lower populations of wetland-dependent plants and animals (Wisconsin DNR 2001b).

Conversion of wetlands from one community type to another deserves special scrutiny. Conversions of sedge meadow, shrub swamp, and lowland forest to open marsh have been common in some areas, and this favors one group of species over others. A better understanding of the site-specific and cumulative impacts of such conversions is needed.

In recent decades, dramatic water level changes shifted the species composition of many of the marshes and sedge meadows bordering the west shore of Green Bay from native plants to invasive species (Meeker and Fewless 2008). In 1986, water levels reached a historic high. During the period from 1997 to 2001, the water levels dropped about 1.25 meters. and reached a historic low. Prior to that time, purple loosestrife was considered to be the most serious of the invasive plants in the bay. It was at this time of low water that several invasive plants "exploded," especially common reed, narrow-leaved cat-tail, and hybrid cat-tail, and became the overwhelmingly dominant species in the west shore marshes, especially in lower Green Bay (Frieswyk and Zedler 2007).

Recent residential developments and the associated infrastructure in the uplands west of Green Bay are altering the hydrology of the highly disturbed but critically important west shore wetlands. These alterations include channelization and redirection of surface flow, interruption of subsurface

flows, excessive groundwater withdrawals, and the addition of contaminants to both surface and ground waters (sediments, fertilizers, pesticides). The practice of digging ponds and creating "waterfalls" within and around new subdivisions has become increasingly common, leading to water waste and hydrological disruption.

In 1872, construction began on a ship canal that was dug across a narrow strip of land on the Door Peninsula to connect Green Bay with Lake Michigan (Bluhm 2012). Prior to the construction of the canal, ships had to make the dangerous voyage around the north end of Door Peninsula through the passage called Port des Mort (Death's Door) by early French explorers for its treacherous currents and rocky shores. The waters of Green Bay and Lake Michigan were connected in 1878, and full operation of the canal began in 1882. Construction of the Sturgeon Bay and Lake Michigan Ship Canal separated formerly connected portions of an extensive coastal ridge-and-swale complex. The ecological impacts that resulted from the connection of Lake Michigan and Green Bay by the canal are unknown.

Dams constructed for hydropower or other purposes fragment river systems, altering their characteristics and often degrading habitats. The dams block the movements of fish and other aquatic organisms.

Contaminants. Contaminants such as polychlorinated biphenyls (PCBs) and mercury have been released into the environment over the years through recycling of carbon paper (PCBs) and burning of coal (mercury). Airborne deposition of these contaminants continues today. In addition, some forms of mercury may occur or be created naturally (Wisconsin DNR and USEPA 2002). The accumulation of PCBs and other contaminants in the sediments of lake and river bottoms as by-products of the paper industry has been significant in this ecological landscape. This has caused physical anomalies and reproductive problems for some fish-eating birds, especially in lower Green Bay (Central Lake Michigan Coastal Ecological Landscape). Gulls, terns, eagles, and cormorants have all been known to be affected adversely by high contaminant loads. Populations of Double-crested Cormorants, Ringed-billed Gulls, and Herring Gulls have increased dramatically on Lake Michigan and Green Bay over the last 30 years (Matteson et al. 1999).

See Chapter 8, "Central Lake Michigan Coastal Ecological Landscape," for a more detailed discussion of Double-crested Cormorant populations and management efforts. See the "Water Quality" section for a discussion of efforts to cleanup contaminants in this ecological landscape.

Health advisories that suggest limits to the amount and type of fish for humans to safely consume have been in place for several decades. The waters of Lake Michigan, Green Bay, and their tributaries are listed with fish advisories for PCBs. With the high popularity of sport fishing in this ecological landscape, contaminants will continue to be an important health issue.

Fish Stocking. Stocking programs of nonnative trout and salmon in Lake Michigan established a sport fishery in these waters and helped to control the exotic alewife. Since the chinook salmon die-off during the late 1980s and early 1990s, the nonnative salmonid sport fishery on Lake Michigan has rebounded (Wisconsin DNR 2001a). That die-off may have been triggered by stocking too many predators for too small a prey base. It is symptomatic of what can happen in the complex, disturbed, and unstable Lake Michigan ecosystem today. A better understanding of how this complex system works is critical to the success of future management.

Management Opportunities for Important Ecological Features of the Northern Lake Michigan Coastal Ecological Landscape

Natural communities, waterbodies, and other significant habitats for native plants and animals have been grouped together as "Ecological Features" and identified as management opportunities when they

- occur together in close proximity, especially in repeatable patterns representative of a particular ecological landscape or group of ecological landscapes;
- offer compositional, structural, and functional attributes that are important for a variety of reasons and that may not necessarily be represented in a single stand;
- represent outstanding examples of natural features characteristic of a given ecological landscape;
- are adapted to and somewhat dependent on similar disturbance regimes;
- share hydrological linkage;
- increase the effective conservation area of a planning area or management unit, reduce excessive edge or other negative impacts, and/or connect otherwise isolated patches of similar habitat;
- potentially increase ecological viability when environmental or land use changes occur by including environmental gradients and connectivity among other important management considerations;
- accommodate species needing large areas or those requiring more than one habitat;
- add habitat diversity that would otherwise not be present or maintained; and
- provide economies of scale for land and water managers.

A site's conservation potential may go unrecognized and unrealized when individual stands and habitat patches are managed primarily as stand-alone entities. A landscape-scale approach that considers the context and history of an

Outstanding Ecological Opportunities in the Northern Lake Michigan Coastal Ecological Landscape

- The cold waters and dynamics of Lake Michigan have a strong influence on climate, geology, landform, and vegetation all along the eastern side of the Door Peninsula and throughout the Grand Traverse Islands.
- The lake and the bay provide significant spawning areas for fish, and shoreline habitats and nearshore waters host large numbers of migrating, wintering, and resident birds.
- Door County's embayment lakes are associated with coniferous forests, marshes, and fen-like wetlands and provide significant habitat for rare plants, invertebrates, and many wildlife species.
- The Niagara Escarpment runs along the west side of the Door Peninsula and through the Grand Traverse Islands. Dolomite cliffs, talus slopes, spring seeps, bedrock ledges, and ancient forests are among the escarpment habitats that support highly specialized plants and animals, including global rarities.
- The northern Door Peninsula provides the setting for a unique assemblage of landforms, natural community complexes, and species assemblages.
- Shoreline complexes such as beach and dune, ridge and swale, freshwater estuary, and bedrock shore support many rare natural communities, which in turn provide habitat for numerous habitat specialists, including rare species.
- This ecological landscape supports a major concentration of rare plants and animals, including species that occur nowhere else in Wisconsin, and some that are Great Lakes endemics.
- The west shore of Green Bay features extensive wetlands of marsh, sedge meadow, shrub swamp, and hardwood swamp.
- Green Bay is shallow, highly productive, and dynamic. Its size, funnel-like shape, and water level fluctuations have created unusual conditions, which have produced distinctive landforms and influenced the extent, location, configuration, and structure of the bay's extensive wetlands.
- Lowland forests of white cedar, tamarack, and ash are abundant in the poorly drained terrain east and north of Lake Noquebay.
- At a few locations there is potential to connect the narrow but critically important strips of coastal forest on the edges of the Door Peninsula via wetlands that occupy some of the larger transverse valleys that cross this land.
- Warmwater rivers and streams flow into Green Bay from the west and contribute to the maintenance of the extensive west shore wetlands as important spawning areas for fish, while providing feeding and nesting areas for many waterbirds.
- The lower Wolf River corridor merits additional protection as it is highly significant for many rare species and common species here and in ecological landscapes downstream. It also provides a major conduit of forested habitat through intensively developed landscapes from which most of the natural vegetation has been removed.

area, along with the types of communities, habitats, and species that are present, may provide the most benefits over the longest period of time. This does not imply that all of the communities and habitats associated with a given opportunity should be managed in the same way, at the same time, or at the same scale. We do suggest that planning and management efforts incorporate broader management considerations and address the variety of scales and structures approximating the range of natural variability in an ecological landscape—especially those that are missing, declining, or at the greatest risk of disappearing over time.

Both ecological and socioeconomic factors were considered when determining management opportunities. Integrating ecosystem management with socioeconomic activities can result in efficiencies in the use of land, tax revenues, and private capital. This type of integration can also help to generate broader and deeper support for sustainable ecosystem management. Statewide integrated opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book.

Significant ecological management opportunities that have been identified for the Northern Lake Michigan Coastal Ecological Landscape include

- Lake Michigan, Great Lakes shoreline features, and the Grand Traverse Islands
- Green Bay's west shore
- Niagara Escarpment

- Lower Wolf River corridor
- Rare species populations and their habitats
- Critical habitat for migrating, wintering, and breeding birds
- Extensive wetlands north and east of Lake Noquebay
- Warmwater streams entering Green Bay
- Miscellaneous ecological features such as forests and surrogate grasslands

Natural Communities, community complexes, and important habitats for which there are management opportunities in this ecological landscape are listed in Table 15.2**.** Examples of some locations where these important ecological places may be found within the ecological landscape are on the map entitled "Ecologically Significant Places of the Northern Lake Michigan Coastal Ecological Landscape" in Appendix 15.K at the end of this chapter.

Lake Michigan, Great Lakes Shoreline Features, and the Grand Traverse Islands

The area discussed here includes much of the Door Peninsula, the Grand Traverse Islands, and the nearshore waters of Lake Michigan and Green Bay, which support a complex of natural communities, geologic features, and habitat specialists offering unique conservation and management opportunities.

East of the Door Peninsula, the waters of Lake Michigan are deep, cold, and relatively clean. The lake has a strong influence on the peninsula's climate, which is cooler and receives more precipitation than inland sites at comparable latitudes. Large numbers of migratory and resident waterbirds use the lake's waters as foraging and resting areas. Terrestrial birds—migrants and residents—disproportionately use terrestrial habitats within several miles of the shoreline. Submerged reefs and rocky shoals are used as spawning areas by fish, including commercially important species such as the lake whitefish.

Moonlight Bay, coastal wetlands, with portion of ridge-and-swale complex visible in upper right. Biodiversity values here are extremely high. Door County. Photo by Eric Epstein, Wisconsin DNR.

The Door Peninsula's Lake Michigan shoreline features an unusual and distinctive array of landforms and vegetation types. Characteristic coastal features include ridge-and-swale complexes, freshwater estuaries, embayment lakes, exposures of dolomite bedrock shore, and an island archipelago that extends north and eastward from the northern tip of the Peninsula into the state of Michigan. Important natural communities include several that occur only along the Great Lakes shores, such as Great Lakes Beach, Great Lakes Dune, Interdunal Wetland, and Great Lakes Alkaline Rockshore.

Bedrock habitats are especially important for rare plants. Dolomite outcroppings occur as shoreline "shelves," low cliffs, and ledges at many locations on the Door Peninsula. Those away from the immediate shore or from the Niagara Escarpment (discussed below) merit additional survey attention form botanists and invertebrate specialists.

Also of special significance is the conifer-dominated Boreal Forest community, which in Wisconsin was historically most prevalent in the Lake Superior coastal zone and which is very rare this far south. Dominant trees include white spruce, balsam fir, northern white-cedar, and eastern white pine. The best examples occur in a narrow strip on the

Arctic primrose (Wisconsin Special Concern) is disjunct from the boreal regions to the north. It grows in cold, moist microhabitats on the Door Peninsula, in the Apostle Islands of Lake Superior, and on a few cliffs in southwestern Wisconsin's Driftless Area. Photo by Drew Feldkirchner, Wisconsin DNR.

Table 15.2. *Natural communities, aquatic features, and other selected habitats associated with each ecological feature within the Northern Lake Michigan Coastal Ecological Landscape.*

Ecological features[a]	Natural communities,[b] aquatic features, and other selected habitats
Lake Michigan shoreline features	Boreal Forest Northern Dry-mesic Forest Northern Mesic Forest Northern Sedge Meadow Shore Fen Emergent Marsh Interdunal Wetland Clay Seepage Bluff Great Lakes Alkaline Rockshore Great Lakes Barrens Great Lakes Beach Great Lakes Dune Great Lakes Ridge and Swale Complex Embayment Lake Grand Traverse Islands Great Lakes Estuary
Green Bay's west shore	Southern Dry-mesic Forest Southern Hardwood Swamp Floodplain Forest Northern Wet-mesic Forest Alder Thicket Shrub-carr Northern Sedge Meadow Southern Sedge Meadow Emergent Marsh Submergent Marsh Riverine Mud Flat
Niagara Escarpment	Northern Dry-Mesic Forest Northern Mesic Forest Southern Mesic Forest Talus Forest Alvar Dry Cliff Moist Cliff
Lower Wolf River corridor	Northern Hardwood Swamp Floodplain Forest Alder Thicket Shrub-carr Southern Sedge Meadow Emergent Marsh Wild Rice Submergent Marsh
Rare species	Plants Animals: dragonflies, land snails, birds Among the plants and insects are several Great Lakes endemics.
Critical habitat for migrating, wintering, and breeding birds	Grand Traverse Islands Shoreline and nearshore habitats along Lake Michigan and Green Bay Major river and stream corridors, e.g., those of the Menominee, Peshtigo, Oconto, and Wolf

Continued on next page

Table 15.2, *continued*.

Ecological features[a]	Natural communities,[b] aquatic features, and other selected habitats
Extensive wetlands north and east of Lake Noquebay	Northern Hardwood Swamp Northern Wet-Mesic Forest Tamarack Swamp Alder Thicket Northern Sedge Meadow Open Bog Emergent Marsh
Warmwater streams entering Green Bay	Warmwater River Warmwater Stream
Miscellaneous (scattered) opportunities to protect and manage more isolated occurrences of natural communities, aquatic features, and rare species populations	All forest communities Boreal rich fen Ephemeral Pond Coldwater Stream Coolwater Stream Inland Lake

[a]An "ecological feature" is a natural community or group of natural communities or other significant habitats that occur in close proximity and may be affected by similar natural disturbances or interdependent in some other way. Ecological features were defined as management opportunities because individual natural communities often occur as part of a continuum (e.g., prairie to savanna to woodland, or marsh to meadow to shrub swamp to wet forest) or characteristically occur within a group of interacting community types (e.g., lakes within a forested matrix) that for some purposes can more effectively be planned and managed together rather than as separate entities. This does not imply that management actions for the individual communities or habitats are the same.

[b]See Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book for definitions of natural community types.

northeastern side of the Door Peninsula and at a few places in the more northerly Grand Traverse Islands.

The coastal forests occur in unusual settings, such as stabilized dunes, abandoned beach ridges, or shallow soils over horizontal bedrock strata. Besides the very rare boreal type, these forests include mesic stands of sugar maple-beech and sugar maple-red maple-beech and hemlock. Dry-mesic forests composed of oaks and pines occur here, often on stabilized beach ridges, though such forest communities are more widely distributed in the sandy parts of northern and central Wisconsin. Unless severely disturbed or altered, many of these Door Peninsula forests have the potential to support unusual understory plants of limited Wisconsin distribution.

The biota of the Lake Michigan coastal zone includes many rare species, including several, such as dwarf lake iris, dune thistle (Pitcher's thistle), sand-reed grass, and Lake Huron locust, that are endemic to the Great Lakes shoreline environments. Also noteworthy is the heavy use that shoreline habitats receive from both breeding and migratory birds (Feucht 2003, Broetzman and Howe 2004).

Dolomite pavement (Great Lakes Alkaline Rockshore) on Hog Island, part of the Grand Traverse Islands Archipelago north of the Door Peninsula. Photo by Emmet Judziewicz.

Management Opportunities, Needs, and Actions

- Because so many of the shoreline features are either unique to this ecological landscape or rare for various reasons, they are high priorities for protection and appropriate management. Private and public conservation groups have done an excellent job, individually and collectively, of identifying and protecting many ecologically important sites (Grimm 1994, The Door County Land Use Forum 1999).
- Establish functional connections between individual conservation sites where needed, creating corridors, working to increase the effective conservation area of other protected lands, and ensuring compatibility of land and water uses that have the potential to affect those sensitive features identified as candidates for priority conservation attention.
- The public lands planning process can play an important and positive role by identifying those ecological features

that are most important to protect and manage in a given property and ecological landscape and ensuring that the new plans do not compromise the condition or viability of the most sensitive features—whether they are rare or viewed as representative. This is especially important for species, habitats, and communities that cannot be effectively conserved elsewhere in the state.

- Several decades ago, a proposal was made to create a chain-of-islands state park between Wisconsin and Michigan (J.L. Huntoon, Wisconsin DNR, unpublished report). For the time being, the Wisconsin DNR has opted not to pursue this possibility, but other agencies (USFWS), including local governments and private organizations (local land trusts), are working to secure protection for additional lands in the Grand Traverse Islands.
- Over the past three decades, the numbers of several colonial nesting birds have increased greatly, especially on islands off of the Door Peninsula. Herring Gulls, Ring-billed Gulls, and Double-crested Cormorants are responsible for the majority of this increase. American White Pelicans first nested on Hat Island in 2001, did not return in 2002, but have been nesting there since 2009. Caspian Terns are nesting in large numbers on Gravel and Pirate islands off the Door County coast, and Common Terns were nesting on Gravel Island in 2011 (S. Matteson, Wisconsin DNR, personal communication).
- Several of the colonial nesters are presently rare in Wisconsin, including the Caspian Tern and Black-crowned Night-Heron.
- One result of the explosive increase in numbers of nesting gulls and cormorants has been the rapid destruction of vegetation, especially on the smaller islands of less than 10 hectares. Several authors have remarked on how rapidly such destruction can occur on islands (Judziewicz 2001). Some of this damage may be irreversible, at least from the temporal perspective of human generations (Hogg and Morton 1983).
- Beach and dune environments are exceptionally attractive to humans because of their recreation and development potential and for their aesthetics. Though these are dynamic communities, dependent on disturbance from water and wind for their maintenance, they can be easily damaged and functionally compromised by excessive use, incompatible developments, and the spread of invasive species such as Lyme grass and common reed.
- Interdunal Wetland communities occur within dune systems and often support rare species. They are fragile, are sometimes short-lived, and can be easily damaged by incompatible uses or hydrological disruption.
- Ridge-and-swale complexes are rare geological features that support exceptionally diverse vegetation mosaics, including species assemblages that are rare or restricted in distribution. Ridge-and-swale environments are sensitive to hydrologic alterations, and the protection of hydrologic function in these systems should be a conservation priority. The larger ridge-and-swale occurrences cover thousands of acres and support many forest interior species, including some that are disturbance sensitive. Such sites may also provide special habitats and niches, such as stands of old-growth conifers or American beech, spring seeps, and fens. Such sites are of great importance to nesting birds as well as to foraging and resting migrants.
- The invertebrate assemblages of the large embayment lakes on the east side of the Door Peninsula (e.g., Clark, Kangaroo, Europe) need further evaluation.
- Surveys of bedrock habitats should be expanded to include dolomite outcroppings away from shoreline areas.
- Some forest communities on the Door Peninsula have a significant component of species such as eastern white pine or northern red oak, which require periodic disturbance if they are to be maintained. Additional management guidelines are needed for such forests to ensure not only their perpetuation but to ensure that compositional and structural features associated with these types are always present. Historically, wildfire provided these disturbances, but the use of fire as a management tool in an area as heavily developed as the Door Peninsula will require detailed coordination, education, and outreach.
- Northern white-cedar is experiencing reproductive failure at many locations here, as it is throughout almost all of its Wisconsin range. In many areas this is due to excessive deer browse. Cedar forests here provide key habitat for many rare plants and birds, and their maintenance in this ecological landscape is a high priority. There are locations on the Door Peninsula where cedar is reproducing well and even invading old fields. This may in part be a

Great Lakes beach and dune complex, with dry-mesic forest of eastern white and red pines, northern red oak, and red maple on adjacent stabilized dunes. Newport State Park, Door County. Photo by Eric Epstein, Wisconsin DNR.

Northern white-cedar occurs with American beech and other hardwoods on stabilized dunes near Lake Michigan. Canada yew was formerly an abundant understory plant here but has diminished greatly in recent years. Whitefish Dunes State Park, Door County. Photo by Eric Epstein, Wisconsin DNR.

Sister Islands, part of the Grand Traverse Archipelago, northeastern Green Bay. These small islands support rookeries of nesting birds. Photo by Eric Epstein, Wisconsin DNR.

palatability issue, associated with the Peninsula's highly alkaline substrates. A more diverse forage base, which includes agricultural crops and residential plantings, may also be important here compared to food availability at locations in the heart of Wisconsin's North Woods where cedar reproduction is now extremely poor.

- Formerly vigorous and extensive populations of Canada yew (*Taxus canadensis*) have crashed recently at sites on the east side of the Door Peninsula, including Whitefish Dunes State Park, Meridian County Park, and on private lands north of Clark Lake. As this area is one of Wisconsin's last strongholds for Canada yew and other similarly sensitive plants, the reasons for its sudden and rapid decline need to be understood and addressed as soon as possible.
- The least disturbed freshwater estuary on Wisconsin's Lake Michigan coast is the Mink River Estuary, near Rowley's Bay. This complex of open wetlands, shrub swamps, and forest communities is dependent on functional hydrologic processes, which may be threatened by increased development and infrastructure expansion. Groundwater recharge areas may extend far beyond the boundaries of the wetland vegetation directly associated with the estuary, and better information on what it will take to ensure the viability of this site over time is needed in the near future. Excessive groundwater withdrawals, disruption of flow patterns, and contaminants in the ground water are among the threats.
- At a few locations, for example along some stream corridors and via extensive wetlands, creating or reestablishing functional ecological connections between Green Bay and Lake Michigan across the Door Peninsula may still be possible. This will become increasingly important over time, as coastal and interior environments change.

Green Bay's West Shore

The west shore of Green Bay is an almost level plain with little topographic relief. Extensive wetlands occur in an almost continuous band from the mouth of the Fox River at the head of the Bay (at the city of Green Bay, in the Central Lake Michigan Coastal Ecological Landscape). Emergent marshes are abundant, and sedge meadows and shrub swamps are also widespread and important. In some places, the coastal marshes have been diked off and no longer have a direct connection to the hydrological dynamics of the Green Bay ecosystem. The long-term implications of this are unclear for an ecosystem as dynamic as Green Bay, but in part this was apparently an attempt to stabilize and maintain marsh vegetation within the diked areas.

A large forested wetland of almost 10,000 acres, County Line Swamp, occurs on the Oconto-Marinette county line. Deciduous trees, including ashes, elms, and soft maples, are generally dominant, but scattered conifers are present, either as individuals or small residual stands. Conifers such as northern white-cedar and tamarack were apparently much more common prior to the Cutover of the late 19th century (Finley 1976). Significant stands of swamp hardwoods also occur west and south of the mouth of the Peshtigo River.

At a few locations, well-developed Floodplain Forests of silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*) are present, providing habitat for species that are otherwise scarce or absent this far north. The best example occupies a several mile stretch of the lower Peshtigo River floodplain. Forests of this type also occur at the northwestern edge of the Northern Lake Michigan Coastal Ecological Landscape along the Menominee River.

Unusual landforms are present at several locations along Green Bay. These include an extensive and complex delta at the mouth of the Peshtigo River; "Charles Pond," composed of sandspits, mud flats, emergent marsh, shrub swamp, and swamp hardwoods south of Pensaukee, which periodically features an enclosed lagoon (high water in the mid-1980s altered the configuration of this site, and it has not returned

Complex pattern of pools, wetlands, and sandbars at the mouth of the Peshtigo River. Marinette County. Photo by Eric Epstein, Wisconsin DNR.

Beach pools are ephemeral features dependent on fluctuating levels of Lake Michigan for their existence. Shorebirds are among the species for which such habitats are important. Photo by Emmet Judziewicz.

Outer bar, Peshtigo River delta at Lake Michigan. Marinette County. Photo by Emmet Judziewicz.

to its former state); and Seagull Bar, a sandspit and lagoon partially enclosing a floristically rich marsh at the mouth of the Menominee River that sometimes attracts large numbers of migrating shorebirds. Other landforms of geological interest as well as great ecological significance include sites in Lower Green Bay, such as Little Tail Point and Long Tail Point. However, these are in the Central Lake Michigan Coastal Ecological Landscape just to the south.

Inventories were conducted by DNR's Bureau of Endangered Resources and others in 2007 in conjunction with master plan development for the Green Bay West Shores State Wildlife Area. Natural communities, vascular plants, and breeding birds were the primary targets of these surveys. During the early 1990s, the U.S. Fish and Wildlife Service undertook surveys of all Green Bay wetlands. Information may still be needed on invertebrates and certain invasive species. The latter have had enormous impacts on the Green Bay ecosystem in recent decades.

Major rivers entering Green Bay from the west include the Menominee, Peshtigo, and Oconto. (The largest, and in many ways, still the most important river entering Green Bay is the Fox, which flows into the head of Green Bay in the Central Lake Michigan Coastal Ecological Landscape, just to the south). Cities and industries have been sited along most of these waterways, and agricultural uses are significant within their watersheds. The Pensaukee and several other small streams also enter Green Bay from the west. Impacts of these and other land uses (such as log drives during the Cutover), have severely diminished water quality in the past, but many efforts have been undertaken to rectify water quality problems.

Nonpoint pollution, due to agricultural activities, road construction, and residential and industrial development, has been identified as a major environmental stressor for Green Bay and its tributary streams, along with residential development, the increase in invasive species, and hydrological alterations (Harris 1993). The dynamic nature of the Green Bay ecosystem ensures that some of the changes there can occur within a very short time span. These changes have been difficult if not impossible to predict, and some of the bay's wetland ecosystems are now on trajectories that are hard to project.

Although the bay has been badly damaged, functional restoration may still be feasible, especially where common fish, wildlife, and habitat management goals have been identified by public and private partners.

Management Opportunities, Needs, and Actions

- Support research studies and monitoring projects of the Green Bay ecosystem that will have application to more successful management of the west shore wetlands. The exceptionally dynamic nature of the Bay has confounded many attempts to predict future changes to the Bay ecosystem, limiting the effectiveness of past and present management and protection efforts, across program and jurisdictional boundaries.
- Revise or amend existing management plans to best address current management challenges. On state lands that can be

accomplished in part by updating master plans for existing state properties. On other properties, including some of those on the Door Peninsula and along Green Bay's west shore, broad-based groups consisting of agency personal, academics, NGO staff, and others have been working on issues of mutual concern, such as invasive species control and restoring hydrological function by reestablishing ecological connections within streams and between streams and wetlands.

- Better inventory information is needed on the wetland and upland ecosystems adjoining Green Bay's west shore. In recent years, surveys of natural communities and for breeding birds have been conducted on state lands by Wisconsin DNR staff from various programs to support property master plan development.
- Identify and protect from further encroachment by development or invasive species the most intact sites along the west shore, such as the Peshtigo Harbor Unit of the Green Bay West Shores State Wildlife Area.
- Examine the restoration potential for formerly important lowland conifer species (northern white-cedar, tamarack, spruces) at selected sites along the Green Bay west shore.
- Nonpoint pollution has been identified as a major problem affecting water quality in the Bay, along with the spread of invasive species, poorly planned residential development, and hydrologic alterations. Each of these needs to be addressed at the site level, by local units of government, and from a watershed perspective by the appropriate entities.
- Sources of excessive sediment and nutrient loads should be identified and reduced in areas where problems have been documented by using best management practices (BMPs), better watershed level land use planning, and by offering support for practices that will address this issue.
- Restoration of functional values has become the goal for some of the more disturbed areas, especially those that have been overrun by common reed and narrow-leaved cattail. In the worst cases, restoration to previous conditions seems unattainable, and the successional trajectory of the affected vegetation is not well understood. Precisely which functional values should be the focus of restoration—how that restoration might be accomplished is among the problems needing additional discussion and clarification.
- Identify and give high priority to the protection of wetlands that are hydrologically linked to the rivers and streams flowing into Green Bay.
- Monitor water quality and quantity and sediment and pollutant inputs to Green Bay and the west shore wetlands.
- The identification of factors that limit populations of ecologically and socioeconomically important fish that spawn in Green Bay and/or its tributaries remains a priority for researchers and managers. Continue to collect, analyze, and summarize data to refine management strategies and make them more effective.
- Install fish passage structures at hydroelectric dams on the Menominee River to allow lake sturgeon and other aquatic species to access spawning, foraging, and wintering habitats, with safeguards to prevent the expansion of invasive species and diseases from Green Bay above the dams.
- Continue to assess the lake sturgeon population in the Menominee River.

Niagara Escarpment

The Niagara Escarpment is part of a Silurian dolomite bedrock feature that underlies much of the Door Peninsula. The steep face of the escarpment is exposed as sheer cliffs at many locations on the western edge of the Door Peninsula, and to the north and east on several of the Grand Traverse Islands. Ecological attributes associated with the escarpment include wet and dry cliffs, talus slopes, spring seeps, ancient trees, and, in some areas, extensive forests. The cliffs, talus slopes, and seepages associated with the Niagara Escarpment support many unusual species, including globally rare terrestrial land snails, some of them known from no other habitats. Other significant features associated with the escarpment and its habitats include rare plant populations, unusual natural communities and species assemblages, and northern white-cedar trees that have reached several centuries in age.

Development has been increasing along some stretches of the Niagara Escarpment, due in large part to the spectacular viewshed. Even when the rock exposures per se are not directly affected, drainage patterns may be altered by roads

Exposures of the Niagara Escarpment along Green Bay are often embedded within dense coniferous forests of northern white-cedar, balsam fir, red pine, and eastern white pine (hardwoods are dominant away from bluff face). Dolomite cobbles and boulders cover the ground at water's edge below the escarpment. Northern Door County. Photo by Eric Epstein, Wisconsin, DNR.

and ditches in ways that deprive some of the specialized plants and invertebrates from needed moisture. Removing trees from the escarpment may diminish or eliminate the leaf litter upon which some of the rare invertebrates are dependent. Quarries, of course, have direct impacts on the escarpment and its biota.

The Niagara Escarpment arcs across the Great Lakes region to the north and east across the northern ends of lakes Michigan and Huron, as far as eastern New York and Vermont (Lake Champlain). For additional information on the Niagara Escarpment, see the Niagara Escarpment Resource Network website (NERN 2014).

Management Opportunities, Needs, and Actions

- Accelerating residential and infrastructure development are among the important factors contributing to hydrological disruption as well as the increased isolation of the remaining undisturbed exposures and patches of escarpment forest.
- Continue Wisconsin DNR work with The Nature Conservancy, the Door County Land Trust, and other private and public partners to identify, manage, protect, and monitor sensitive escarpment sites.
- Local governments may have the best opportunities to ensure that developments proposed for the Niagara Escarpment are compatible with ensuring their continued ecological viability.
- The effective management of ground and surface waters will become increasingly challenging problems for managers and conservationists to meet. Understanding site hydrology is critical to effective protection efforts.
- Significant exposures of the escarpment occur on public lands on the Door Peninsula, including several state and county parks. The management plans for those properties need to be developed or updated with knowledge that is relevant to maintenance of the escarpment and its sensitive attributes (e.g., hydrology, the habitat needs of bedrock specialists and other rare species, the management and maintenance of adjacent forest habitats, invasive species).
- Several of the Grand Traverse Islands contain sensitive stretches of the Niagara Escarpment, especially Washington and Rock islands. Important bedrock exposures also occur on other islands, but they are not all part of the Niagara Escarpment per se. Exposures of the Silurian dolomite also occur as low, nearly horizontal expanses of rockshore.
- Lands containing portions of the escarpment that are proposed for housing development, business expansion, communication tower or wind turbine siting, road construction, or quarrying should be surveyed thoroughly for rare species prior to project approval.

Lower Wolf River Corridor

The Wolf River is one of eastern Wisconsin's largest rivers and is of great importance to many native plants and animals. As the Wolf River leaves the Menominee Indian Reservation and enters the western edge of the Northern Lake Michigan Coastal Ecological Landscape, the river's gradient drops, and a significant floodplain begins to develop. The lower Wolf begins below the Shawano dam, very close to the Northern Lake Michigan Coastal Ecological Landscape's northwestern boundary. The dam prevents free movement of aquatic organisms and is treated as the boundary between the upper and lower Wolf. The stretch of the Wolf River within this ecological landscape is somewhat transitional and may be more vulnerable to disruption and degradation than stretches to the north where the watershed is mostly forested. Farther south, in the Central Lake Michigan Coastal Ecological Landscape, a much broader, well-developed floodplain is present.

Though only a short stretch of the Wolf River occurs within this ecological landscape, its protection is very important. Below Shawano, the historically dominant land cover of forest has been largely removed from the uplands, agriculture is now the dominant land use, and agricultural fields now comprise the bulk of the land cover. The floodplain begins to widen in this stretch but not nearly to the degree that it does a short distance farther south. The river is therefore vulnerable to activities that reduce water quality and its capability of supporting a high diversity of aquatic life, including a number of rare or otherwise sensitive species.

Below the Shawano dam, the Wolf River is free-flowing all the way to its mouth at Lake Poygan, the westernmost of the Winnebago Pool lakes.

At the southern end of the Northern Lake Michigan Coastal Ecological Landscape the character of the Wolf River changes dramatically. Upstream (to the north) above the Shawano Dam, the Wolf is fast-flowing and bordered mostly by upland forest. Downstream, south all the way to the Winnebago Pool lakes, the gradient is low, the floodplain becomes very broad, and the river and adjoining wetlands support a high diversity of native fish, birds, herps, and invertebrates. Photo by Eric Epstein, Wisconsin DNR.

Management Opportunities, Needs, and Actions

- Protection of water quality is of critical importance along this stretch of the Wolf River because the floodplain is narrow, wetland vegetation is limited in extent, rare species are present, and buffering is minimal.
- Monitor water quality and quantity in this stretch of the Wolf River, as activities here will impact the river farther downstream. Populations of sensitive aquatic organisms should be monitored. Coordinate with parallel work along the Wolf downstream in the Central Lake Michigan Coastal and Southeast Glacial Plains ecological landscapes.
- Help ensure that local land use planners and resource managers are aware of the ecological, as well as the recreational and economic, values of the Wolf River system because all of these are high. These values increase and are magnified downstream because the floodplain becomes more extensive and offers extensive habitat for many sensitive species (Epstein et al. 2002b), including some that are associated with wetlands and adjoining uplands.
- Implement Wolf River watershed management recommendations to protect water quality and habitat values of sensitive areas along the river (updated in 2010). These include developing a strategy to manage bank erosion from intensive boat usage, working closely with East Central Wisconsin Regional Planning Commission Staff to include important water resources in the town of Wolf River resource inventory, and working with land county conservation departments and Natural Resources Conservation Department staff to monitor and assess the water quality status of subwatersheds.

Rare Species Populations and their Habitats

The Door Peninsula is justly noted for harboring one of the upper Midwest's great concentrations of rare plants. In recent years, the significance of this ecological landscape to rare animals has been underscored by the discoveries of rare dragonflies, land snails, and birds. Colonial birds are especially well represented here the Grand Traverse Islands provide relatively remote and secure rookery locations.

The areas bordering and influenced by the Great Lakes support regional endemics. These species are found nowhere else in the world but in specific environments associated with the Great Lakes shorelines. Regional endemics occurring in this ecological landscape include dwarf lake iris, dune thistle (Pitcher's thistle), Lake Huron tansy, and Lake Huron locust. Dwarf lake iris and dune thistle are both listed as U.S. Threatened. Other species of special management concern inhabit rare, geographically restricted, or otherwise unusual communities and habitats such as bedrock features, northern fens, boreal forest, beach and dune complexes, and islands. Extensive habitats, such as the Green Bay west shore marshes and the free-flowing stretches of the lower Wolf River, also support significant populations of rare species.

Management Opportunities, Needs, and Actions

- The Door Peninsula and Grand Traverse Islands, owing to the influence of climate, geographic location and orientation, landforms, geologic processes, and vegetation, constitute one of Wisconsin's most important repositories for rare plants and animals. These include Great Lakes endemics such as dwarf lake iris and dune thistle (Pitcher's thistle)—both listed as U.S. Threatened and Wisconsin Threatened—and the Lake Huron locust and Lake Huron tansy—both listed as Wisconsin Endangered; global rarities such as the rare terrestrial snails of the Niagara Escarpment and the Hine's emerald dragonfly; and many species that are rare at the state level (several of which occur in no other location or ecological landscape in Wisconsin). Birds, invertebrates, and vascular plants are among the taxa especially well represented by rare species in the Northern Lake Michigan Coastal Ecological Landscape.
- Other locations here that support noteworthy concentrations of rare species include the wetlands along the west shore of Green Bay, which are of great value to birds and fish, and the lower Wolf River, a diverse aquatic ecosystem rich in rare mussels, dragonflies, fish, and birds.
- Survey dolomite outcroppings away from Lake Michigan and Green Bay. Usually these are ledges or low cliffs, and in general, they have not been surveyed as thoroughly as the coastal bedrock exposures.
- Provide natural resource managers with information on the rare species for which they are responsible, including location, phenology, habitat preferences and associations, management needs and guidelines (if any, and if they are known), and threat vulnerability, and support research that will help to clarify problems identified by those managers or others. If specific management information for a given species is not available, encourage local institutions

This alkaline pond is ringed with open, shrubby, and forested peatlands. These are fens, not bogs. Unnamed pond on the Door Peninsula, Door County. Photo by Eric Epstein, Wisconsin DNR.

to develop projects that will yield information that may be applied by managers to maintain populations of these rare species.

- Habitat damage or destruction due to excessive deer browse, exotic earthworms, invasive plants, and the proliferation of several species of colonial nesting birds is already occurring in some areas and is likely to increase in significance over time. Monitoring is needed, and planners and managers need the resources to deal with such problems because they have now become a significant part of the workload in maintaining or restoring the viability of natural systems throughout this ecological landscape and beyond.
- Habitats known to support rare species, particularly highly specialized or area-dependent organisms, may be highly vulnerable to damage from unplanned or poorly planned land uses. Obvious examples include beach and dune systems, other shoreline habitats, sites on or associated with the Niagara Escarpment, and large, relatively unbroken patches of forest. Serious damage may also occur due to hydrologic disruptions, the addition of excessive amounts of sediments, nutrients, and pollutants to surface and ground waters, and the spread of invasive species.

Critical Habitat for Migrating, Wintering, and Breeding Birds

Lake Michigan and Green Bay are heavily used by migrating waterbirds, including waterfowl, loons, grebes, gulls, terns, shorebirds, cormorants, and herons. Large numbers of terrestrial birds, including neotropical migrants and raptors, migrate along both sides of the Door Peninsula (especially in the spring), the west shore of Green Bay (especially in the fall), and throughout the north-south Wolf River Corridor.

Significant habitats for breeding birds include mixed conifer-hardwood forests, especially in the coastal areas of the Door Peninsula; the marshes, sedge meadows, and lowland forests along Green Bay's west shore; and the Grand Traverse Islands (especially for colonial nesting birds). Surrogate Grasslands (hayfields, fallow fields, lightly grazed pastures) close to Lake Michigan formerly provided sensitive grassland birds with suitable nesting habitat. However, in recent years grassland birds here have declined significantly, apparently due to both successional and land use changes. If surveys indicate that sensitive birds are still present, and if appropriate management protocols can be designed to maintain enough open habitat to support these populations, perhaps grassland management is warranted. At the present time, prospects for grassland wildlife here do not appear bright—at least not at large scales.

In some of these currently open or semi-open upland areas, reforestation would be a higher priority and better opportunity than grassland management.

Several sites along the eastern shore of the northern Door Peninsula, including the nearshore waters, and others on the west shore of Green Bay, including the lower Peshtigo River and Seagull Bar, were recently approved as Important Bird Areas (Steele 2007).

Management Opportunities, Needs, and Actions

- Access the adequacy of available habitat for sensitive breeding birds, particularly for marsh and forest nesters but also for habitat specialists (e.g., species dependent on islands as nesting sites, or those that are associated with specific habitats such as sedge meadows, beaches, or dunes), and develop plans to address shortcomings where they can be addressed effectively.
- Provide sufficient high quality habitat to meet the needs of migratory birds, and work to connect, buffer, or enlarge sites in areas that are identified as critical. Priority areas include both sides of the Door Peninsula, the west shore of Green Bay, and perhaps the Wolf River Corridor, which runs north-south near the western edge of the ecological landscape.
- Develop a network of sites, especially on the Door Peninsula and along the west shore of Green Bay, at which migratory birds can be monitored systematically, at regular intervals.
- Monitor breeding birds at coastal wetlands along Green Bay's west shore and the Door Peninsula. See Hanowski et al. (2007) for additional information on monitoring bird populations in Great Lakes coastal wetlands.
- More information is needed on important wintering habitats and sites, especially for uncommon or very locally distributed species, such as Greater Scaup, Long-tailed Duck, and the three scoter species. Coordination will be needed with other jurisdictions in other ecological landscapes if we expect to manage successfully for migratory birds over the long-term.
- An assessment is needed for the environmental impacts of new technologies, such as the commercial generation of wind energy or biofuel production, that have the potential to impact populations of birds, bats, and other organisms.

Extensive Wetlands North and East of Lake Noquebay

The lands north and east of Lake Noquebay and south and west of the Menominee River are poorly drained and feature extensive wetlands. Common and widespread plant communities in this part of the ecological landscape include Northern Wet-mesic Forest (both white cedar swamp and northern hardwood swamp are present), tamarack swamp, and Alder Thicket. Northern Sedge Meadow and Emergent Marsh are also present but are less extensive than the other types. Bottomland hardwoods, including northeastern Wisconsin's northernmost stands of Floodplain Forest, occur along the lower Menominee River.

Additional inventory of natural communities, aquatic features, and other potentially significant habitats in this area is highly desirable, including the Menominee River from Marinette upstream to "the Oxbow" (a site three miles east of Wausaukee); the extensive wetlands south and west of the Menominee River, including those associated with Upper Inlet and Middle Inlet Creeks, which feed Lake Noquebay; and the streams and wetlands that drain south into the Peshtigo River. Better information, gathered from field surveys, is needed to adequately assess the condition, composition, and conservation potential of this portion of the Northern Lake Michigan Coastal Ecological Landscape. This area has not been comprehensively surveyed but is known to support some very rare species, including lake cress, shining lady's-tresses, and the rare slaty skimmer dragonfly.

Management opportunities in this part of the Northern Lake Michigan Coastal Ecological Landscape have not been adequately clarified, primarily because of the lack of detailed information on ecosystem type, structure, and composition. Vegetation patterns differ from those elsewhere in the ecological landscape because of the drumlin influence.

Management Opportunities, Needs, and Actions

- Compile existing information on natural features and land use history of this area from local resource managers, scientists, naturalists, and nearby institutions such as UW-Green Bay.
- Identify information gaps, determine how an assessment of ecosystems in this area might best be conducted, develop a plan to provide the needed information, and secure support.
- Continue to assess of dam impacts on the water quality, water quantity, and aquatic biota of the Menominee River. Evaluate success of planned sturgeon passage lifts after they have been made operational.
- Work with public and private landowners to protect or restore sensitive shoreline habitats along the Menominee and Peshtigo rivers and the lakes along Upper Inlet Creek.

Warmwater Streams Entering Green Bay

Important warmwater rivers and streams entering Green Bay from the west include the Peshtigo, Oconto, and Pensaukee. Industrial pollution has been a past problem; nonpoint pollution (nutrients and sediments) continues to have negative impacts on water quality in the streams and in Green Bay. Improving in-stream connectivity via better use of culverts or other means is an important management need, especially for fish (Schuette and Rost 1998). Maintaining, improving, or restoring connectivity between streams and adjacent wetlands is also a management priority, as is bank protection.

Wetlands along west shore streams are found not only along the shore of Green Bay but extend inland up to several miles and can be important spawning sites for species such as northern pike and support a host of other wetland species. These are found along the Suamico, North Branch of the Oconto (at Peshtigo Brook), lower Peshtigo, Wausaukee and lower Menominee rivers.

Management Opportunities, Needs, and Actions

- Monitor sediment, nutrient, and pollutant inputs to these rivers and streams and identify the sources.
- Develop a plan to reduce inputs of materials that degrade water quality in the rivers and in Green Bay.
- Identify important instream and streamside habitats and develop a plan to increase their protection or restoration.

Miscellaneous Ecological Features

Forests

Farms and cities have mostly replaced the vast mesic forests that covered almost the entire Northern Lake Michigan Coastal Ecological Landscape prior to settlement by Euro-Americans. Remnants of these upland forests now often occur as farm woodlots and as relatively small areas within parks or other protected areas. Other forest types occur in poorly drained depressions, within river floodplains, on shorelines, and on rocky or sandy sites of low fertility. The best opportunities to manage for relatively large blocks of forest and associated biota occur on the margins of the Door Peninsula, at a few locations on the west shore of Green Bay, in the floodplains of several of the larger rivers, and in the poorly drained areas east and north of Lake Noquebay.

Large blocks of interior forest have been greatly diminished here. Forest communities in need of greater representation here include mesic hardwoods and hemlock hardwoods, especially stands with a significant component of American beech. Historically, the interior of the Door Peninsula was almost entirely forested with these types. The current forest is now much more limited in extent, occurring mostly in coastal

Extensive mesic forests with embedded wetlands occur at a few locations on the Door Peninsula, including Peninsula State Park (shown here). Photo by Eric Epstein, Wisconsin DNR.

Second-growth mesic hardwood forests now comprise the prevalent forest cover in much of northern Wisconsin. This stand is on the Door Peninsula in the eastern part of the state and contains a substantial component of American beech, which is limited to Wisconsin's easternmost counties. American beech is now greatly reduced in abundance here due to the destruction of hardwood forests in eastern Wisconsin. American beech is an important species because of its size, longevity, appearance, potential dominance, and the mast it produces in some years. Oconto County. Photo by Drew Feldkirchner, Wisconsin DNR.

areas or in areas where the dolomite bedrock is too close to the surface to permit intensive agricultural or residential uses.

This is one of the ecological landscapes in which reforestation could play a significant role in creating more viable and better connected forest habitat for sensitive species. There is potential here to increase the amount of forest as a means of sequestering carbon because most of the forests here support or could support large, long-lived tree species. If planned and implemented properly, this activity would not conflict with important grassland or savanna habitats, as it has the potential to do in parts of Wisconsin where grasslands and savannas are important to restore, manage, and maintain. Old-growth forests (Wisconsin DNR 2006a) were historically common and widespread throughout much of the Northern Lake Michigan Coastal Ecological Landscape. Such forests are now rare virtually everywhere in Wisconsin (Frelich 1995). Opportunities to protect and manage them appropriately do exist here (Wisconsin DNR 2006a), and opportunities should be identified and pursued.

As an additional point of interest with respect to old growth forests, some of Wisconsin's oldest trees—these include eastern red and northern white cedars—grow on undisturbed stretches of the Niagara Escarpment. Old-growth forests are now restricted to a few Door Peninsula shoreline areas (where they are not necessarily secure, nor do these forests types represent all of the forest communities found throughout the ecological landscape). Several State Natural Areas and privately owned and managed conservation lands have the potential to develop old-growth forests, but most of these sites are small and scattered and do not represent all of the forest types present in the ecological landscape.

Dry forests of pine, oak, and aspen still occur in the sandier areas west of Green Bay, e.g., between the Oconto and Pensaukee rivers. Additional inventory of natural communities and selected taxa is needed to better understand the management potential of this area.

A special case might be made for protection of the extensive privately owned forests on 2,800-acre Chambers Island. Chambers is low and sandy and geologically very different from the other Grand Traverse Islands. Developments are limited to shoreline cabins, a lighthouse and dock (the island's only public land), a small airstrip, and a two-track dirt road, and much of the interior is intact, though much of this is used as a "working forest." Eastern hemlock, northern red oak, and American beech are among the trees common in the forests of Chambers Island. Eastern white pine was abundant historically. Protection appears most likely to be achieved through partnerships with individual landowners (some of whose holdings are quite large), The Nature Conservancy and other land trusts, and the Wisconsin DNR.

Chambers Island features sandy shoreline habitats along Green Bay that have escaped the development and heavy foot traffic that has damaged so many similar habitats on the mainland. The beach flora is relatively intact, and several rare plants have been documented in undeveloped shoreline areas. One of Wisconsin's very few examples of the extremely rare Great Lakes Barrens community has been described here (it's very small but has a strong prairie component, unlike Great Lakes Barrens occurrences on Lake Superior).

Portions of the Northern Lake Michigan Coastal Ecological Landscape may be suitable for reforestation, especially in areas where formerly extensive and contiguous regional forest has been severely fragmented. Locations to consider would include the coastal areas of the Door Peninsula, where core areas exist but where the forests have now been reduced to narrow strips, and areas that might someday provide forested connections across the Peninsula. Areas where agriculture has been abandoned or reduced from previous levels and where the bedrock is close to the surface, may offer opportunities in the near term. Benefits would include reduced habitat edge and isolation, increased ability to support area sensitive species, and more extensive and viable migratory stopover areas.

If growing forests to increase carbon sequestration is seriously considered in Wisconsin, this is one of the ecological landscapes in which historical condition, capacity of the land to grow large, old trees, ecological need, lack of conflict with sensitive grassland or early successional ecosystems in other parts of the state, and aesthetic considerations line up well and in which multiple benefits might be realized. The most obvious choices for protecting additional forest in the immediate future might be focused on the Door Peninsula and on the corridors of the larger rivers, especially the Menominee, Wolf, Oconto, and Peshtigo.

Surrogate Grasslands (Including Agricultural Fields on Some Parts of the Door Peninsula)

Due to the combination of heavy soils, which are slow to warm in the spring, and the influence of Lake Michigan on local climate, plant growth in areas close to Lake Michigan can be slower than at inland locations. This can delay harvest, creating opportunities to manage for some grassland birds, even in areas dedicated to agricultural uses that often lead to their decline or elimination as successful nesters (Sample and Mossman 1997). For example, Wisconsin's breeding bird atlas (Cutright et al. 2006) shows one of Wisconsin's few concentrations of the Wisconsin Special Concern Upland Sandpiper in this ecological landscape. Recently, some of these areas (especially more marginal farmland) are apparently no longer productive for grassland birds. Habitat changes, including encroachment by woody species and residential development, are thought to be the main causes (D. Sample, Wisconsin DNR, personal communication).

Small, even isolated, sites containing features that are rare and/or poorly represented elsewhere are also legitimate targets of protection efforts. Other features worthy of protection and management include undeveloped ecosystem "connectors," especially along Lake Michigan, Green Bay, and the aforementioned corridors of the Wolf, Menominee and Peshtigo rivers. Springs and seepages, and good examples of natural communities also deserve consideration for management attention.

Socioeconomic Conditions

Socioeconomic information is summarized within county boundaries that approximate ecological landscapes unless specifically noted as being based on other factors. Economic data are available only on a political unit basis, generally with counties as the smallest unit. Demographic data are presented on a county approximation basis as well since they are often closely associated with economic data. The multi-county area used for the approximation of the Northern Lake Michigan Coastal Ecological Landscape is called the Northern Lake Michigan Coastal counties (Figure 15.9). The counties included are Marinette, Oconto, Shawano, and Door because at least 25% of each county lies within the ecological landscape boundary.

History of Human Settlement and Resource Use

American Indian Settlement

The reconstruction of pre-historical events, cultures, themes, and timelines through archaeological studies is complex and changes through time as more discoveries are made. This section attempts to describe the current prevailing views of these factors as they relate to the Northern Lake Michigan Coastal Ecological Landscape. For more information on all of the general time lines, cultures, traditions, themes, and tribes statewide, please see the "Statewide Socioeconomic Assessments" section of Chapter 2, "Assessment of Current Conditions," in Part 1 of this publication.

The Northern Lake Michigan Coastal Ecological Landscape has long been inhabited, with the first evidence dating to the Paleo-Indian Tradition. The Cardy site in Door County, now believed to have been destroyed by the expansion of the City of Sturgeon Bay, yielded fluted points that are diagnostic of the early Paleo-Indian peoples (Mason 1997). This site was on high ground on top of the Niagara Escarpment, which appears to have been on or near the shoreline of Lake Algonquin, the predecessor of current Lakes Michigan and Huron.

One very interesting site in present-day Oconto County was a cemetery site associated with the Middle Archaic Tradition. This is one of only four excavated sites in Wisconsin that were exceptionally rich in copper artifacts, associating them with the Old Copper complex (Stoltman 1997). (The Old Copper complex used to be considered its' own culture but is now considered to be a technological phase associated with many cultural affiliations during the Archaic Tradition.) The Oconto County cemetery site has been destroyed by development.

By the time of the transition between the Archaic and Woodland Traditions, the Northern Lake Michigan Coastal Ecological Landscape began to be more heavily occupied. There are several excavated sites with Woodland Tradition characteristics on the shorelines of Door County, including on Rock Island (Stevenson et al. 1997).

Approaching historical times, the Northern Lake Michigan Coastal Ecological Landscape was heavily occupied by Oneota

Figure 15.9. *Northern Lake Michigan Coastal counties.*

peoples, especially in Door County (Overstreet 1997). By the time of Euro-American contact, the Oneota had largely abandoned their holdings in eastern Wisconsin and moved further south and west. It is generally accepted that the Oneota are the forbearers of the Ho-Chunk, but direct evidence of this relationship is elusive.

At the time of Euro-American contact, the Menominee lived in this area, having at one time occupied a region stretching from present-day Minnesota to Chicago. Further, their 10-million acre hunting range stretched from Lake Michigan in the east to the Yellow, Chippewa, and Red Cedar rivers in the west (The Wisconsin Cartographers' Guild 1998). Here their land overlapped with that of the Ho-Chunk, Ojibwe, and Dakota tribes. This territory was rich in wild game, fish, and wild rice and was an integral part of the trade route between the Great Lakes and the Mississippi River.

U.S. control of these lands began in 1817 with the acquisition of the land around Fort Howard near Green Bay on the Fox River (The Wisconsin Cartographers' Guild 1998). Over the next thirty years, the Menominee ceded large chunks of land to the United States government. In 1854, the tribe was "awarded" their current reservation, adjacent to the Stockbridge-Munsee reservation in Shawano County, in the Forest Transition Ecological Landscape. The Menominee Reservation today comprises more than 230,000 acres, and its boundaries are congruent with Menominee County, almost all of which is outside of the Northern Lake Michigan Coastal Ecological Landscape.

The Potawatomi arrived in Wisconsin in the mid-17th century during the Iroquois wars. The Potawatomi, or "keepers of the sacred fire people," settled originally around Green Bay and the Door Peninsula as well as on some of the Grand Traverse Islands. By 1820, about 10,000 Potawatomi lived in 100 villages throughout eastern Wisconsin (The Wisconsin Cartographers' Guild 1998). Lands ceded to the United States through the 1829 Treaty of Prairie du Chien and the 1833 Treaty of Chicago, however, greatly diminished the tribe's land holdings in the state. Currently, a portion of the Potawatomi Reservation, established officially in 1988, lies in this ecological landscape.

Euro-American Contact and Settlement

French fur traders, missionaries, and soldiers began arriving in the region during the mid-17th century. These early Europeans made contact with the American Indians and consequently set up trading posts, missions, and forts along lakes and river routes. By 1820, hunting and trapping in northern Wisconsin had depleted the wildlife resource, resulting in the fur trade moving father north into Canada. Soon after, American Indian tribes began ceding their lands to white settlers.

While Belgian, French, and Polish immigrants settled this area of the state intermittently, the two largest settlement groups proved to be German and Icelandic. Forty-seven percent of Wisconsin residents claim Germany as their first ancestry. The largest concentration has been in the eastern region of the state, including the Northern Lake Michigan Coastal region. Icelandic immigrants began arriving in this area of the state during the 1870s. Washington Island, off the tip of the Door Peninsula, is the oldest established Icelandic settlement in the United States. By 1924, over 1,000 Icelandic immigrants had settled in northern Door County and on Washington Island, relying mainly on fishing, lumbering, and farming for their subsistence (The Wisconsin Cartographers' Guild 1998).

Early Agriculture

Permanent Euro-American settlement began in earnest in the Northern Lake Michigan Coastal counties after 1850. Officially, permanent Euro-American settlement began in Door and Oconto counties at their founding in 1851. Shawano County was founded shortly thereafter in 1853. Marinette County was established in 1879 (following the 1871 Peshtigo fire that severely burned parts of what became Marinette County) (National Association of Counties 2010). By 1860, there were reportedly only 257 established farms in Northern Lake Michigan Coastal counties (ICPSR 2007). By 1870, the number of farms had grown to 1,195 while the population had reached 16,406.

The population continued to grow in each of the subsequent decades until reaching 114,513 in 1920; thereafter, the population fluctuated as did the number of farms. Farm numbers continued to grow in Northern Lake Michigan Coastal counties, reaching 12,018 farms in 1920 (Figure 15.10). Farm numbers actually decreased in the 1920s, with the onset of the depression driving some marginal farmers out of production. However, farm numbers had swelled again by 1940 to 12,085. Meanwhile population in Northern Lake Michigan Coastal counties fluctuated and fell behind statewide population growth rates in more urban areas.

During and following World War II, farm numbers again began to decline as mechanization and urbanization combined to increase the average size of farms (Figure 15.11). That trend continued throughout much of the remaining 20th century. Farms tended to be slightly smaller on average in Northern Lake Michigan Coastal counties than in the state as a whole. In 1950, farms in Northern Lake Michigan Coastal counties averaged 132.2 acres compared to 137.8 acres statewide (ICPSR 2007).

Total value of all crops indicates the extreme influence of the Great Depression on agriculture. In 1910, all crops harvested in the Northern Lake Michigan Coastal counties had an estimated total value of $7.3 million, which nearly tripled by 1920 ($20.6 million) (ICPSR 2007). However, total value of all crops in the Northern Lake Michigan Coastal counties plummeted in 1930 ($12.1 million) and fell further in 1940 ($9.3 million) as a result of the Great Depression. Total values of crops in the Northern Lake Michigan Coastal counties comprised 5.5% of total crop value in the state in 1940, and these crops came from farms comprising 6.1% of all Wisconsin farm acreage. Farms in the Northern Lake Michigan

Coastal counties historically have not been as productive as in the state as a whole, but during and immediately following the Great Depression the Northern Lake Michigan Coastal counties actually gained market share in terms of crop value in the state.

Over the early part of the 20th century, the type of farming in the Northern Lake Michigan Coastal counties underwent some fundamental shifts as Wisconsin became established as a leader in the dairy industry. Northern Lake Michigan Coastal farms increasingly grew "hay and forage" crops and grew less "cereals" as farms matured. The 1910 agricultural census listed "cereals" as 39.2% of the total value of all crops harvested in the Northern Lake Michigan Coastal counties, but cereals comprised as little as 24.4% of total crop values in 1930, recovering only to 27.9% by 1940 (ICPSR 2007). Meanwhile, "hay and forage," associated with livestock farming, was 30.8% of total value of crops harvested in the Northern Lake Michigan Coastal counties in 1910 and had risen to 48.6% of total crop value by 1940.

Early Mining

Extensive mining did not occur in the Northern Lake Michigan Coastal counties. The Northern Lake Michigan Coastal counties were instrumental in the transport of mining products, however, providing a viable route of transport to eastern markets.

Early Transportation and Access

In 1673, Marquette and Jolliet established a route across Wisconsin from Green Bay to the Mississippi River via the Fox and Wisconsin rivers. Early Euro-American settlers to the region found an extensive network of Indian trails throughout the territory. Following the end of the Black Hawk War in 1832, these trails were widened into roads suitable for ox carts and wagons due to the rapid settlement and population growth during the 1830s (Davis 1947). A system of military roads was developed in Wisconsin around the same time, connecting key cities and forts. One of the first of these military roads connected Fort Howard at Green Bay with Milwaukee and Racine. Another road was constructed between Fond du Lac on Lake Winnebago and the Fox and Wisconsin rivers. From 1837 to 1848, territorial legislatures had authorized the establishment of 243 other territorial roads. By 1870, however, the importance of railroads had caused highways to become of secondary value.

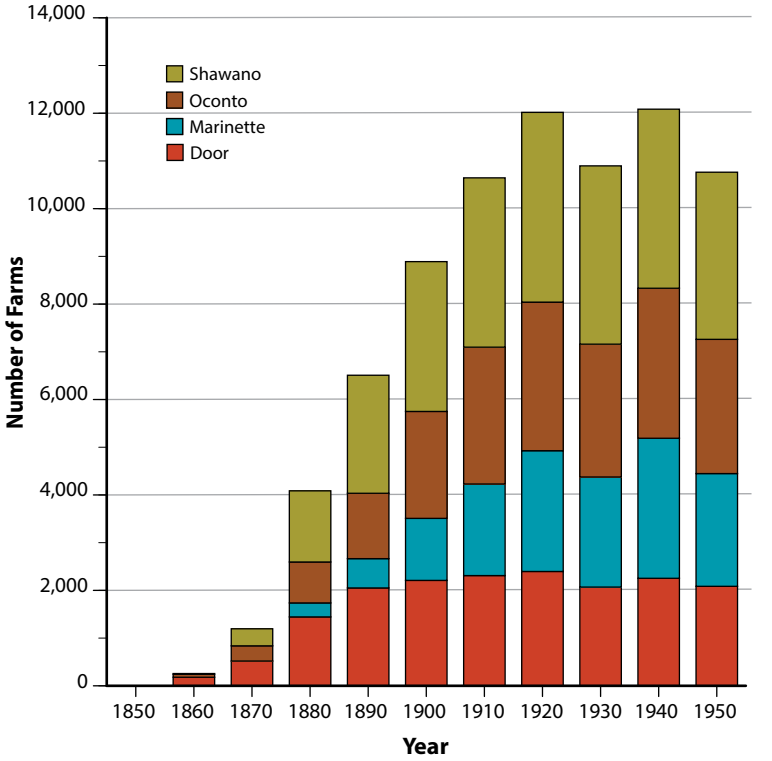


Figure 15.10. *Number of farms in Northern Lake Michigan Coastal counties between 1860 and 1950 (ICPSR 2007).*

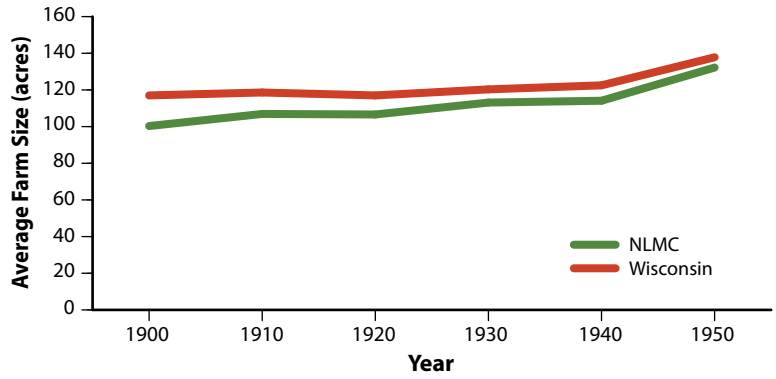


Figure 15.11. *Average farm size in Northern Lake Michigan Coastal counties between 1900 and 1950 (ICPSR 2007).*

While the Northern Lake Michigan Coastal region of Wisconsin was not a prime destination for railroad lines, several lines did terminate in or incorporate Green Bay, including the Green Bay and Western line. Additional lines in the area included the Wisconsin Northwestern Railroad, and the Peshtigo Harbor Railroad; both operated in Marinette County. The Peshtigo Harbor Railroad was one of the longest running railroads in the area, operating from 1862 until 1918 (Fisher 1937).

Early Logging Era

The logging industry became established in Northern Lake Michigan Coastal Ecological Landscape in the latter half of the 19th century. Extensive fires often followed logging when the slash and debris left from

logging operations was burned. Eastern white pine was the original tree of choice, and after its depletion, loggers turned to eastern hemlock and hardwoods. Access to trees and delivery to sawmills was expedited by the network of waterways that were used to float logs to the mills. Scouring of river bottoms and deposition of bark and other woody debris changed the character of many rivers. Subsequent transportation of logs to mills was facilitated by the establishment of railroads. The timber industry attracted settlers and helped support other economic activities in the four Northern Lake Michigan Coastal counties, such as agriculture, mining, housing construction, and railroad building, which in turn helped support the timber industry.

In the Green Bay logging district, lake schooners were also used from Marinette-Menominee, Oconto, and Green Bay to ship lumber to cities on Lake Michigan, especially to the big lumber yards in Chicago. The last of the three-masted schooners, the *Lucia A. Simpson,* was built in 1875. She carried lumber and forest products for fifty years (Rosholt 1980).

Wisconsin's first sawmill was built in this region of the state at De Pere in 1809. Another soon followed just outside of Green Bay in 1814 (Austin 1948). Additional mills in the vicinity of the Northern Lake Michigan Coastal Ecological Landscape included others in the Green Bay area and one at Oconto (The Wisconsin Cartographers' Guild 1998).

Roth (1898) described forest conditions in some of the northern Wisconsin counties at the close of the 19th century. (Door County was not part of Roth's survey.) In Marinette County, he noted that pine had been harvested in parts of each township. The greater part of this county was described as a pinery (especially, though not exclusively, in the Northeast Sands Ecological Landscape). The Peshtigo Fire in 1871 burned over much of the area along Green Bay, which was formerly pine mixed with hardwoods (and swamp conifers). After the fire, it was bare or brushland, with some settlement. Roth estimated that 1.5 billion board feet of pine remained in Marinette county at the turn of the 20th century. Other remaining sawtimber was estimated to be 500 million board feet, half of which was hemlock. Noted hardwoods were maple, birch, and basswood, with oak being rare. Large burned-over wastes existed in all parts of the county. By comparison, today there are 700 million board feet of pine, 74 million board feet of eastern hemlock, and one billion board feet of hardwood sawtimber in Marinette County forests (USFS 2009).

Pine was cut in nearly all parts of Oconto County during the Cutover. Only 65 to 75 million board feet remained standing in 1897 (Roth 1898). Eastern hemlock was estimated at 500 million board feet and hardwoods at 400 million board feet. Hardwoods were principally birch, American basswood, elm, maple, and ash, with little oak. The lower part of the county was cut-over, with much of it bare and a large part settled. Today there are 587 million board feet of pine, 63 million board feet of eastern hemlock, and 709 million board feet of hardwood sawtimber in Oconto County (USFS 2009).

The southeastern one-third of Shawano County was formerly covered by a heavy forest of pine mixed with hardwoods. The northwestern two-thirds was a very heavy mix of eastern hemlock, hardwoods, and pine. The pine was almost all cut by 1897 (Roth 1898). Roth estimated 650 million board feet of eastern hemlock and 700 million board feet of hardwoods, primarily American basswood, elm, and maple, remained. Barren "stump prairies" occurred in all parts of the county at the end of the 19th century. Today there are 247 million board feet of pine, 60 million board feet of eastern hemlock, and 656 million board feet of hardwood sawtimber in Shawano County (USFS 2009).

Resource Characterization and Use[1]

The Northern Lake Michigan Coastal Ecological Landscape has about 1,974 square miles of land and only 30.5 square miles of surface water. Its population density, 40 persons per square mile, is fairly low compared to the statewide average of 105 persons per square mile (USCB 2012). In terms of current and potential recreational use, there is less public land in the Northern Lake Michigan Coastal Ecological Landscape than any other ecological landscape in the state. However, the density of private and public campgrounds is above average as is the number of visitors to state properties. The density of multi-purpose trails is the highest in the state. Acreage in natural areas is lower than average, but there are more Land Legacy sites with high recreation potential.

Agriculture and forestry are not major factors in the economy of the Northern Lake Michigan Coastal Ecological Landscape. This region ranks slightly below average in terms of the percentage of land in agriculture and in net income from farming. Both milk and corn production is about average for the state. The region ranks below average in the percentage of land that is forested and in total growing stock volume and removals.

The density of roads, railroads, and runways in the Northern Lake Michigan Coastal Ecological Landscape is about average for the state. There are five airports and three major ports. This ecological landscape has six hydroelectric plants, which is above average for the state. There are no wind or ethanol plants in this ecological landscape at this time; however, the potential for wind development is being closely examined in Lake Michigan off of the Door Peninsula.

The Land

Of the 1.26 million acres of land that make up the Northern Lake Michigan Coastal Ecological Landscape (excludes area of open water), 36% is forested. About 87% of all forested land is privately owned while 13% belongs to the state, counties or municipalities (USFS 2009).

[1]When statistics are based on geophysical boundaries (using GIS mapping), the name of the ecological landscape is followed by the term "ecological landscape." When statistics are based on county delineation, the name of the ecological landscape is followed by the term "counties."

Minerals

Of the four Northern Lake Michigan Coastal counties, Marinette and Oconto have some disclosure of mining revenues. In 2007, there were nine mining establishments (Wisconsin DWD 2009). There were 166 workers employed in mining operations in Marinette and Oconto counties with wages of $8.9 million.

Water (Ground and Surface)

Water Supply

The data in this section are based on the DNR's 24K Hydrography Geodatabase (Wisconsin DNR 2012a), which are the same as the data reported in the "Hydrology" section; however, the data are categorized differently here so the numbers will differ slightly. Of the 2,460,212 acres that make up Shawano, Marinette, Door, and Oconto counties, 46,100 acres (1.9%) are surface water. The 1,341 lakes (over one acre) add up to 37,525 acres, which is 81% of the surface water. Kangaroo Lake in Door County is the only lake over 1,000 acres in size. The major rivers and streams in this ecological landscape include the Menominee and Peshtigo in Marinette County, the Oconto, Pensaukee, Little, and Suamico in Oconto County, the Wolf and Embarrass in Shawano County, and the Ahnapee in Door County.

Water Use

Each day, 66.4 million gallons of ground and surface water are withdrawn in the four Northern Lake Michigan Coastal counties (Table 15.3). About 70% of the withdrawals are from surface water. Of the 126,396 people that reside in these counties, 35% are served by public water sources and 65% are served by private wells (USGS 2010). Marinette County accounts for the largest withdrawals, or 73%. The greatest use of water, 39%, is for thermoelectric once-through power generation, though industrial and agricultural uses are also important.

Recreation

Recreation Resources

Land use patterns will partly determine the type of recreation that is available to the public. For instance, in the Northern Lake Michigan Coastal Ecological Landscape, there is a much higher percentage of agricultural land and a lower proportion of forest and grassland compared to the rest of the state (see Chapter 3, "Comparison of Ecological Landscapes," in Part 1 of the book and/or the map entitled "WISCLAND Land Cover (1992) of the Northern Lake Michigan Coastal Ecological Landscape" in Appendix 15.K at the end of this chapter). The inland surface area in water is third lowest, but the proportion of that water in rivers as opposed to inland lakes is above average.

There is less public land in this ecological landscape than in any other ecological landscape in the state, both state and federally owned. However, the density of private and public campgrounds is above average as is the number of visitors to state properties. The density of multi-purpose trails is the highest in the state. Acreage in natural areas is lower than average but the number of Land Legacy sites with high recreation potential is above average.

Dolomite quarry in Niagara Escarpment east of Sturgeon Bay. Door County. Photo by Eric Epstein, Wisconsin DNR.

Supply

Land and Water. The Northern Lake Michigan Coastal Ecological Landscape comprises 3.6% of Wisconsin's total land area but only 1.5% of the state's acreage in inland waters (see Chapter 3, "Comparison of Ecological Landscapes, in Part 1 of the book for comparison of ecological landscape sizes). There are 459,127 acres of forestland, or 2.8% of the total acreage in the state. Although the area in surface water is not great, Lake Michigan, Green Bay, and their shorelines are extremely important to many forms of recreation, including boating, camping, birding, fishing, and sightseeing. Streams and rivers make up 36% of the inland surface water area of the Northern Lake Michigan Coastal Ecological Landscape, and lakes and reservoirs make up over 62% of the area (Wisconsin DNR 2012a). The largest rivers are the Menominee, Peshtigo, Oconto, and Wolf, and the largest lakes include Kangaroo, Clark, and Christie, and Lake Noquebay.

Public Lands. In the Northern Lake Michigan Coastal Ecological Landscape, almost 69,800 acres or 5.4% of all land and water is publicly owned. This is significantly less than the statewide average of 19.5% and ranks 12th out of 16 ecological landscapes in the percentage of public ownership. There are about 19,500 acres of public waters, 26,800 acres of state recreational lands, and 23,400 acres of county forests and State Natural Areas.

State-owned lands and facilities are important to recreation in the Northern Lake Michigan Coastal Ecological Landscape. There are about 9,000 acres in parks and recreation areas, including Peninsula, Newport, Rock Island,

Whitefish Dunes, Copper Culture Mounds, and Grand Traverse Island state parks. In addition, there are 1,174 acres of state trails, including the Mountain Bay and Oconto River trails, and about.12,000 acres of fisheries and wildlife management lands. The largest of these, the Green Bay West Shores Wildlife Area and the Mud Lake Wildlife Area, each provide over 2,000 acres of recreational land (Wisconsin DNR 2005a).

Trails. The Northern Lake Michigan Coastal counties have about 3,190 miles of recreational trails and rank first (out of 16 ecological landscapes) in trail density (miles of trail per 100 square miles of land) (Table 15.4). Compared to the rest of the state, there is a higher density of all trail types with the exception of cross-country skiing (J. Prey, Wisconsin Department of Natural Resources, unpublished data).

Land Legacy Sites. The Land Legacy project has identified over 300 places of significant ecological and recreational importance in Wisconsin, and 22 are either partially or totally located within the Northern Lake Michigan Coastal Ecological Landscape (Wisconsin DNR 2006c). The Niagara Escarpment and Peninsula State Park are rated as having the highest recreation significance. In addition, seven sites are rated as having the highest conservation significance: Eagle Harbor to Toft Point Corridor, the Grand Traverse Islands, the Mink River Estuary and Newport State Park, the Niagara Escarpment, North Bay to Bailey's Harbor, the Peshtigo Harbor Marsh, and Shivering Sands.

Campgrounds. In all, there are 100 public and privately owned campgrounds, which provide 6,627 campsites in the Northern Lake Michigan Coastal counties. With 6% of the state's campgrounds, this ecological landscape ranks 7th (out of 16 ecological landscapes) both in terms of the number of campgrounds and campground density (campgrounds per square mile of land) (J. Prey, Wisconsin Department of Natural Resources, unpublished data).

State Natural Areas. The Northern Lake Michigan Coastal Ecological Landscape has 15,091 acres of State Natural Areas, of which about 50% is publicly owned (including government and educational institutions), 32% is owned by private interests (including nongovernmental organizations, or NGOs), and 18% is owned by joint public-private entities. The largest State Natural Areas in this ecological landscape include Mud Lake (2,556 acres; Door County, part of Mud Lake State Wildlife Area), Mink River Estuary (1,675 acres; Door County), the Ridges Sanctuary (1,187 acres; Door County), North Bay (1,173 acres; Door County), and Cave Point-Clay Banks (1,115 acres; Door County) (Wisconsin DNR unpublished data; for more information regarding State Natural Areas, see Wisconsin DNR 2013b).

Metropolitan Versus Nonmetropolitan Recreation Counties. Johnson and Beale (2002) classified Wisconsin counties according to their dominant characteristics. One classification, "nonmetro recreation" county, is characterized by high levels of tourism, recreation, entertainment, and seasonal

Table 15.3. *Water use (millions of gallons/day) in the Northern Lake Michigan Coastal counties.*

County	Ground Water	Surface Water	Public Supply	Domestic[a]	Agriculture[b]	Irrigation	Industrial	Mining	Thermo Electric	Total
Door	4.7	2.0	1.7	0.9	2.6	1.1	0.2	0.3	–	**6.7**
Marinette	7.8	40.6	4.1	1.3	4.8	1.8	10.2	0.2	26	**48.5**
Oconto	5.0	3.5	1.4	1.3	1.7	0.8	2.8	0.3	–	**8.4**
Shawano	2.3	0.5	0.5	0.7	0.9	0.6	0.1	0.0	–	**2.8**
Total	**19.8**	**46.6**	**7.7**	**4.2**	**10.0**	**4.3**	**13.3**	**0.8**	**26**	**66.4**
Percent of total	**30%**	**70%**	**12%**	**6%**	**15%**	**7%**	**20%**	**1%**	**39%**	

Source: Based on 2005 data from the U.S. Geological survey on water uses in Wisconsin counties (USGS 2010).
[a]Domestic self-supply wells.
[b]Includes aquaculture and water for livestock.

Table 15.4. *Miles of trails and trail density in the Northern Lake Michigan Coastal counties compared to the whole state.*

Trail type	Northern Lake Michigan Coastal (miles)	Northern Lake Michigan Coastal (miles/100 square miles)	Wisconsin (miles/100 square miles)
Hiking	118	3.1	2.8
Road biking	203	5.4	4.8
Mountain biking	118	3.1	1.9
ATV: summer and winter	999	26.5	9.3
Cross-country skiing	263	7.0	7.2
Snowmobile	1,483	39.3	31.2
Total trails	**118**	**3.1**	**2.8**

Source: Wisconsin Department of Natural Resources unpublished data.

housing. Three of the four Northern Lake Michigan Coastal counties are classified as nonmetro recreation counties: Door, Marinette, and Oconto.

Demand

Visitors to State Lands. In 2006, there were an estimated 1.5 million visitors to state properties of the Northern Lake Michigan Coastal Ecological Landscape, almost entirely to the state parks. Two-thirds of these visited Peninsula State Park (Wisconsin DNR unpublished data).

Fishing and Hunting License Sales. Of all license sales, the highest revenue producers for the Northern Lake Michigan Coastal counties were resident hunting licenses (42% of total sales), resident fishing licenses (30% of total sales), and nonresident fishing licenses (14% of total sales) (Wisconsin DNR, unpublished data). Table 15.5 shows a breakdown of various licenses sold in the Northern Lake Michigan Coastal counties in 2007. Marinette County accounts for both the highest number of licenses sold and the highest revenue from sales. This ecological landscape accounts for about 3% of total license sales in the state. However, persons buying licenses in the Northern Lake Michigan counties may travel to other parts of the state to use them.

Recreational Issues

Results of a statewide survey of Wisconsin residents indicate that a number of current issues are affecting outdoor recreation opportunities within Wisconsin (Wisconsin DNR 2006b). Many of these issues, such as increasing ATV usage, overcrowding, increasing multiple-use recreation conflicts, loss of public access to lands and waters, invasive species, and poor water quality, are common across many regions of the state.

Silent Sports Versus Motorized Sports. Over the next decade, the most dominant recreation management issues will most likely revolve around conflicts between motorized and nonmotorized recreation interests. From a silent sport perspective, noise pollution from motorized users is one of the higher causes for recreation conflict (Wisconsin DNR 2006b). Recreational motorized vehicles include snowmobiles, ATVs, motor boats, and jet skis. ATV use is especially contentious. ATV riding continues to be one of the fastest growing outdoor recreational activities in Wisconsin. Many ATV riders feel there is a distinct lack of ATV trails, and they are looking primarily to public lands for places to expand their riding opportunities.

Timber Harvesting. A high percentage of statewide residents are concerned about timber harvesting in areas where they recreate (Wisconsin DNR 2006b). Their greatest concern about timber harvesting is large-scale visual changes (i.e., large openings) in the forest landscape. Forest thinning and harvesting that creates small openings is more acceptable. Silent-sport enthusiasts as a group are the most concerned about the visual impacts of harvesting, while hunters and motorized users are somewhat less concerned.

Loss of Access to Lands and Waters. With the ever increasing development along shoreline properties and continued fragmentation of forest lands there has been a loss of readily available access to lands and waters within this ecological landscape. This may be due to the concentration of housing that has occurred with the advent of housing developments closing large areas of shoreline once open to the casual recreational user. Another element that may play into the perception of reduced access is a lack of information about where to go to recreational opportunities. This element was highly ranked as a barrier to increased outdoor recreation in a statewide survey (Wisconsin DNR 2006b).

Agriculture

Farm numbers in the Northern Lake Michigan Coastal counties have decreased 38% since 1970 (USDA NASS 2004). There were approximately 6,830 farms in 1970 and 4,203 in 2002. Between 1970 and 2002, average farm size increased from 162 acres to 197 acres, which is similar to the statewide average of 201 acres. The overall land in farms has steadily decreased since the 1970s (Figure 15.12). In 1970, there were about 1.1 million acres of farmland, and by 2002, acreage was down to 773,000 acres in the four counties, a decrease of 30%. For the four counties, the percentage of land in farms ranges from 16% to 47%, averaging 31%. The counties with the highest percentage of farm land are Shawano with 47% and Door with 43%.

Agriculture is a significant part of the economy of the Northern Lake Michigan Coastal counties but less than in other ecological landscapes. In 2002, net cash farm income totaled $72 million, or an average of $94 per agricultural acre,

Table 15.5. *Fishing and hunting licenses and stamps sold in the Northern Lake Michigan Coastal counties, 2007.*

County	Resident fishing	Nonresident fishing	Misc. fishing	Resident hunting	Nonresident hunting	Stamps	Total
Marinette	15,205	4,114	851	20,523	592	8,428	49,713
Oconto	9,927	1,236	202	12,177	133	4,798	28,473
Shawano	9,700	1,228	310	11,750	84	3,938	27,010
Door	7,103	4,666	6,252	8,267	121	7,421	33,830

Source: Wisconsin Department of Natural Resources unpublished data, 2007.

about equal to the statewide average of $91 per acre (USDA NASS 2004). Also in 2002, the market value of all agriculture products sold in the Northern Lake Michigan Coastal counties was $285 million (2% of state total); 27% of this amount came from crop sales, while the remaining 73% was from livestock sales.

Door County cherries account for over 95% of all tart cherries produced in Wisconsin. In 2005, Wisconsin produced about 7.2 million pounds of tart cherries (USDA NASS 2009). There are over 2,000 acres of Montmorency tart cherries and 50 acres of sweet cherries grown in Door County. The quantity and quality of fruit depends on the climatic conditions. Lake Michigan tempers the winter winds and cools the orchards in the summer.

In 2007, 4,253 acres of farmland had been sold in the Northern Lake Michigan Coastal counties, of which 94% stayed in agricultural use at an average selling price of $3,433 per acre (USDA NASS 2009). Six percent was diverted to other uses at an average sale price of $23,260 per acre.

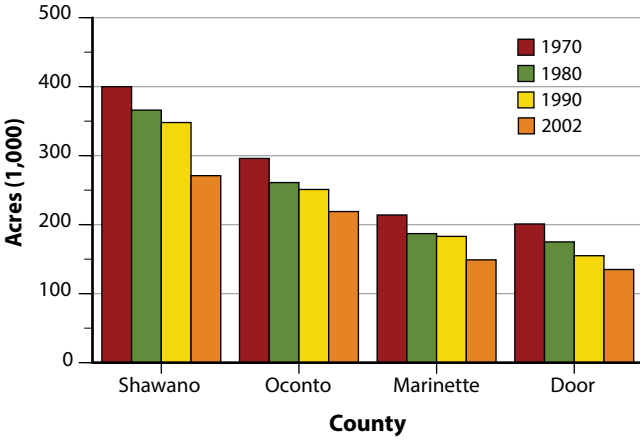


Figure 15.12. *Acreage of farmland in the Northern Lake Michigan Coastal counties by county and year (USDA NASS 2004).*

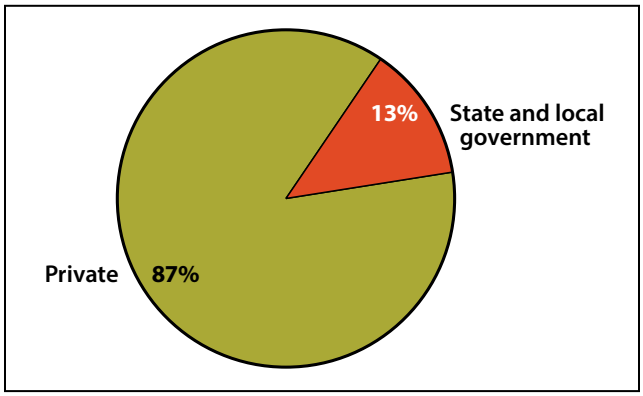


Figure 15.13. *Acreage of timberland by owner group (USFS 2009).*

Timber

Timber Supply

Based on Forest Inventory and Analysis (FIA) data, 36% (459,127 acres) of the total land area for the Northern Lake Michigan Coastal Ecological Landscape is forested (USFS 2009). This is 3% of Wisconsin's total forestland acreage.

Timber Ownership. ***Timberland*** is defined as forestland capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization. Of all timberland within the ecological landscape, 87% is owned by private landowners (USFS 2009; Figure 15.13). The remaining 13% is owned by state and local governments.

Growing Stock and Sawtimber Volume. There was approximately 619 million cubic feet of growing stock volume in the Northern Lake Michigan Coastal Ecological Landscape in 2007, or 3% of total volume in the state (USFS 2009). Most of this volume, 63%, was in hardwoods, less than the proportion of hardwoods statewide, which was 74% of total growing stock volume. Hardwoods comprised a lower percentage of sawtimber volume, or 57%. In comparison, statewide hardwoods were 67% of total sawtimber volume.

Annual Growing Stock and Sawtimber Growth. Between 1996 and 2007, the timber resource in the Northern Lake Michigan Coastal Ecological Landscape increased by 33 million cubic feet or 6% (USFS 2007). All of this increase occurred in softwood volume whereas hardwood volume actually decreased. Sawtimber volume increased by 288 million board feet, or 19%. Most of this change, 64%, occurred in softwood volume.

In the Northern Lake Michigan Coastal Ecological Landscape, timberland acreage decreased from 468,167 to 457,916 acres between 1996 and 2007, compared to an increase of 3% statewide (USFS 2007). A probable explanation for the reduction in agricultural and forest land, as well as hardwood timber volume, is the changing land use to residential use. This is a result of the rapidly increasing population in the Northern Lake Michigan Coastal counties.

Timber Forest Types. According to FIA (USFS 2009), the predominant forest type groups in terms of acreage are maple-basswood (32%), bottomland hardwoods (20%), spruce-fir (15%), aspen-birch (13%), and oak-hickory (1%), with lesser amounts of white, red, and jack pines (see Appendix H, "Forest Types That Were Combined into Forest Type Groups Based on Forestry Inventory and Analysis (FIA) Data," in Part 3 of the book, "Supporting Materials"). Acreage is predominantly in the pole and sawtimber size classes (44% and 36%, respectively) with 18% in seedling and sapling classes (Table 15.6).

Timber Demand

Removals from Growing Stock. The Northern Lake Michigan Coastal Ecological Landscape has about 3% of the total growing stock volume on timberland in Wisconsin. Average annual removals from growing stock were six million cubic

Table 15.6. *Acres of timberland in the Northern Lake Michigan Coastal Ecological Landscape by forest type and size class.*

Forest type[a]	Seedling/sapling	Pole-size	Sawtimber	Total
Sugar maple-beech-yellow birch group	9,250	31,784	41,204	82,238
Northern white-cedar	4,613	38,396	16,746	59,754
Black ash-American elm-red maple group	15,223	23,337	3,275	41,835
Aspen	9,739	20,833	8,827	39,398
Sugarberry-hackberry-elm-green ash group	3,976	15,803	9,905	29,684
Hard maple-basswood group	1,049	3,225	14,174	18,448
Elm-ash-locust group	7,726	8,031	1,024	16,781
White birch	1,994	8,399	6,015	16,408
Red pine	–	2,570	13,741	16,311
Red maple-upland	–	6,934	7,654	14,588
Cherry-ash-yellow-poplar group	5,935	3,970	1,925	11,830
Northern red oak	–	1,043	10,328	11,371
Eastern white pine	–	7,943	2,329	10,272
Post oak-blackjack oak group	5,464	2,036	2,714	10,214
White oak-red oak-hickory group	–	3,327	5,691	9,017
Nonstocked[b]	–	–	–	8,464
Mixed upland hardwoods	2,492	5,697	–	8,188
Red maple-lowland	–	679	5,540	6,219
Willow	6,164	–	–	6,164
Tamarack	2,492	3,322	–	5,814
Balsam poplar	2,098	3,657	–	5,755
Eastern hemlock	–	–	5,254	5,254
Cottonwood	2,888	1,032	963	4,882
White pine-red oak-white ash group	–	4,184	404	4,588
Red maple-oak group	–	1,287	2,540	3,828
White oak	–	–	2,593	2,593
White spruce	–	2,098	–	2,098
Jack pine	1,778	–	–	1,778
Silver maple-American elm group	–	–	1,128	1,128
Black spruce	–	831	–	831
White pine-hemlock group	–	–	800	800
Sycamore-pecan-American elm group	718	–	–	718
Black cherry	664	–	–	664
Total	**84,263**	**200,418**	**164,774**	**457,915**

Source: U.S. Forest Service Forest Inventory and Analysis Mapmaker (USFS 2009).

[a]U.S. Forest Service Forest Inventory and Analysis (FIA) uses a national forest typing system to classify FIA forest types from plot and tree list samples. Because FIA is a national program, some of the national forest types in the above table do not exactly represent forest types that occur in Wisconsin. For example, neither post oak nor blackjack oak occur to any great extent in Wisconsin, but since there is no "black oak forest type" in the FIA system, black oak stands in Wisconsin were placed in the "post oak-blackjack oak" category in this table.

[b]Nonstocked land is less than 16.7% stocked with trees and not categorized as to forest type or size class.

feet, or about 1.8% of total statewide growing stock removals (349 million cubic feet) between 2002 and 2007 (USFS 2009). (See the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes," in Part 1 of the book.) Average annual removals to growth ratios vary by species (major species shown), as can be seen in Figure 15.14. Removals exceed growth for red pine, big-tooth aspen (*Populus grandidentata*), balsam poplar, jack pine (*Pinus banksiana*), and white birch (*Betula papyrifera*). There has been high demand for pulpwood as well as rapid land use change to residential use in the Northern Lake Michigan Coastal Ecological Landscape, which would affect the rate of removals.

Removals from Sawtimber. The Northern Lake Michigan Coastal Ecological Landscape has about 3% of the total sawtimber volume on timberland in Wisconsin. Average annual removals from sawtimber were about 18.8 million board feet or 1.8% of total statewide removals (1.1 billion board feet) between 2000 and 2002 and 2005 and 2007 (USFS 2009). Average annual removals to growth ratios vary by species as can be seen in Figure 15.15 (only major species shown). Sawtimber removals exceeded growth for big-tooth aspen, jack pine, and balsam poplar. As noted with growing stock removals, the high demand for pulpwood as well as rapid land use change to residential use in the ecological landscape would affect the rate of removals.

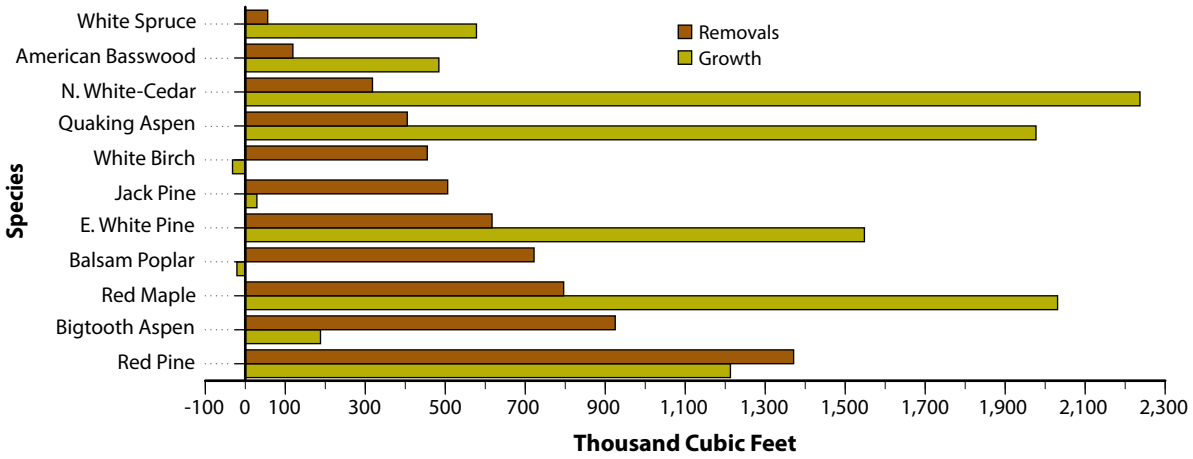


Figure 15.14. *Growing stock growth and removals (selected species) on timberland in the Northern Lake Michigan Coastal Ecological Landscape (USFS 2009).*

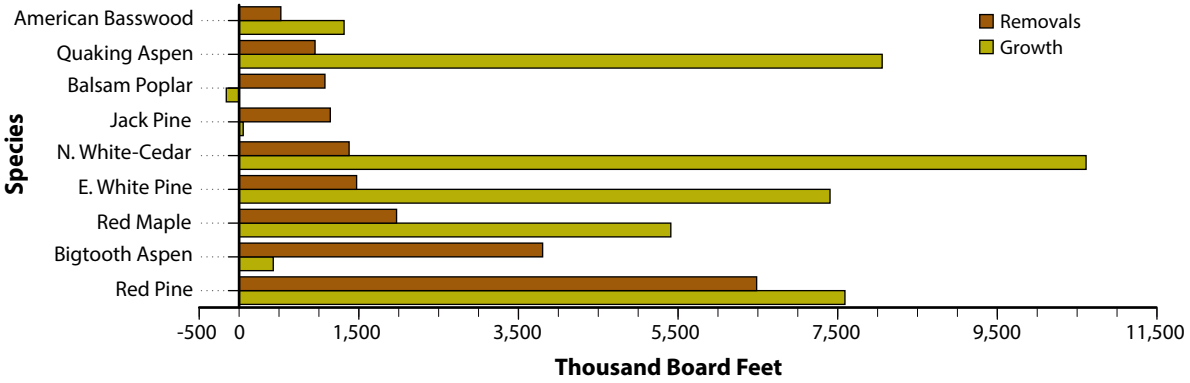


Figure 15.15. *Sawtimber growth and removals on timberland in the Northern Lake Michigan Coastal Ecological Landscape (USFS 2009).*

Price Trends

In the Northern Lake Michigan Coastal counties, sugar maple, northern red oak, and red maple were the highest priced hardwood sawtimber species in 2007. Northern white-cedar, eastern white pine, and red pine were the most valuable softwood timber species. Sawtimber prices for 2007 were generally much lower for softwoods and somewhat lower for hardwoods compared to the rest of the state (Wisconsin DNR 2008). For pulpwood, red pine is the most valuable. Pulpwood values in the Northern Lake Michigan Coastal counties were slightly higher for hardwoods and softwoods compared to the statewide average (Wisconsin DNR 2008).

Infrastructure

Transportation

The transportation infrastructure of the Northern Lake Michigan Coastal Ecological Landscape is generally more developed than that of the rest of the state. For instance, road mile density is 7% higher (Wisconsin DOA 2000), and railroad density is 14% higher (Wisconsin DOT 1998), while airport runway density is 28% lower than the state as a whole (Wisconsin DOT 2012). There are five airports in the Northern Lake Michigan Coastal Ecological Landscape, but none are primary regional airports. There are three ports, one diversified cargo port at Marinette/Menominee and two limited cargo ports at Sturgeon Bay and Washington Island (WCPA 2010) (Table 15.7).

Renewable Energy

Hydroelectric and wind turbine power are the only renewable energy sources quantified by county in Wisconsin (Wisconsin DOA 2006). Some general inferences can be drawn from other sources regarding the potential for renewable energy production in the counties of the Northern Lake Michigan Coastal Ecological Landscape.

Other than woody biomass, the Northern Lake Michigan Coastal Ecological Landscape has a limited potential to produce a significant amount of renewable energy. This ecological landscape has 2% of the state's population and, by inference, the state's energy use. The Northern Lake Michigan

Table 15.7. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports in the Northern Lake Michigan Coastal Ecological Landscape.*

	Northern Lake Michigan Coastal	State total	% of state total
Total road length[a] (miles)	7,212	185,487	4%
Road density[b]	3.7	3.4	–
Miles of railroads	218	5,232	4%
Railroad density[c]	11.0	9.7	–
Airports	5	128	4%
Miles of runway	2.9	95.7	3%
Runway density[d]	1.4	1.8	–
Total land area (square miles)	1,974	54,087	4%
Number of ports[e]	3	14	21%

[a]Includes primary and secondary highways, roads, and urban streets.
[b]Miles of road per square mile of land. Data from Wisconsin Roads 2000 TIGER line files (dataset) (Wisconsin DOA 2000).
[c]Miles of railroad per 100 square miles of land. Data from 1:100,000-scale Rails Chain Database (Wisconsin DOT 1998).
[d]Miles of airport runway per 1,000 square miles of land. Data from Wisconsin Airport Directory 2011–2012 web page (Wisconsin DOT 2012).
[e]Data from Wisconsin Commercial Ports Association (WCPA 2010).

Coastal Ecological Landscape has 5.5% of all woody biomass in Wisconsin, generates 2.4% of hydroelectric power and produces only 2.4% of the state's corn crop (Wisconsin DOA 2006). This ecological landscape does not have any ethanol plants or wind generating sites at this time; however, the potential for wind development is being closely examined in Lake Michigan, off of the Door Peninsula.

Biomass. Woody biomass is Wisconsin's most used renewable energy resource. The Northern Lake Michigan Coastal Ecological Landscape produces 54.4 million oven-dry tons of biomass per year, or 5.5% of total statewide production (USFS 2009). Only 36% of the land base is forested, and this has decreased by 2% in the last decade.

Hydroelectric. There are six hydroelectric power sites, which generate 35.3 million kWh (kilowatt hours) (Wisconsin DOA 2006). In the entire state, there are 68 sites (owned either by utility companies or privately owned) with a total generation of 1,462 million kWh.

Ethanol. The Northern Lake Michigan Coastal counties produces 14.2 million bushels of corn, or 2.4% of total production in the state (USDA NASS 2004). Agricultural acreage for the four counties (currently only 32% of the land base; some woodland is counted as agriculture by this source) decreased by 30% between 1970 and 2002. There are no ethanol plants presently located in the four counties and little future potential for corn-based production (Renewable Fuels Association 2010).

Wind. There are no currently sited or permitted wind farms in the Northern Lake Michigan Coastal ecological landscape (WWIC 2013). Mean annual power densities are generally below 200 W/m^2 in this part of the state (USDE 2013).

Current Socioeconomic Conditions

The Northern Lake Michigan Coastal counties (Marinette, Oconto, Shawano, and Door) are traditionally rural with relatively low population density and housing density but have increasing dependency on both urban centers and tourism hot spots for economic output. The largely homogenous white population of Northern Lake Michigan Coastal counties is growing in urban areas, while rural areas lose population and experience decreased economic activity, especially in places where tourism is less prevalent.

Northern Lake Michigan Coastal counties are experiencing a net ***in-migration*** of retirement-age adults and a net ***out-migration*** of young adults, with negative implications for the available workforce. Door County, with its scenic location and the associated tourism dollars and higher property values in that county, is distinct from its fellow Northern Lake Michigan Coastal counties in terms of many socioeconomic metrics.

Demography

According to 2010 U.S. Census Bureau estimates, the population of the Northern Lake Michigan Coastal counties was 149,143, or 2.6% of the state population (USCB 2012). Seventy-one percent of the population in Northern Lake Michigan Coastal counties can be classified as rural, compared to 31.7% in Wisconsin as a whole. Of six urban centers (defined as cities with at least 2,500 inhabitants) in Northern Lake Michigan Coastal counties, Marinette (population 10,759 in 2007 estimates) is the largest (USCB 2009). Oconto County (though 80.1% of its population is rural) is the only Northern Lake Michigan Coastal County classified as "metropolitan" by the USDA Economic Research Service in 2004. This classification is likely due in part to the influence of Green Bay to the south.

Population Density

Reflecting the region's rural character, the population density in 2010 of the Northern Lake Michigan Coastal counties (40 persons per square mile) is relatively low compared to 105 persons per square mile in Wisconsin as a whole (USCB 2012).

Population Structure

Age. Population in Northern Lake Michigan Coastal counties is older and aging compared to the rest of the state. Approximately 21.2% of the 2010 population in Northern Lake Michigan Coastal counties was under 18 years old, compared to 23.6% statewide. Conversely, 18.9% of the population is 65 or older, compared to 13.7% statewide (USCB 2012). The median age in Northern Lake Michigan Coastal counties ranges from 38.5 years in Shawano County to 42.9 years in Door County, compared to the statewide average of 36 years (USCB 2009).

Minorities. The Northern Lake Michigan Coastal counties are less racially diverse than the state as a whole. Almost 95% of the 2010 population in Northern Lake Michigan Coastal counties is white, non-Hispanic, compared to 86.2% statewide. Only Shawano County, directly south of the Menomonee Reservation, contains a significant American Indian population (7.6%) (USCB 2012).

Education. Northern Lake Michigan Coastal counties' residents 25 years of age or older have relatively lower education levels compared to the state as a whole, especially in terms of higher education. According to the 2010 federal census, 88.2% of Northern Lake Michigan Coastal counties' residents 25 or older have graduated from high school, compared to 89.4% statewide (USCB 2012). Almost 17% of Northern Lake Michigan Coastal counties' residents have received at least a bachelor's degree or higher, compared to 25.8% statewide. Door County has significantly higher education attainment levels than other Northern Lake Michigan Coastal counties, with 92.5% of residents graduated from high school, and 27.5% having attained at least a bachelor's degree or higher. It is fair to assume that the higher educational levels in Door County are a result of the net in-migration of retirees.

Population Trends

Over the extended period from 1950 to 2006, Northern Lake Michigan Coastal counties' combined population has grown at a slower rate (26% population growth) than has the state's population (62%) (USCB 2009). However, population trends in the Northern Lake Michigan Coastal counties have changed over time. From 1950 to 1960, Northern Lake Michigan Coastal counties endured negative population change (-2.8%) with population losses in each of the four Northern Lake Michigan Coastal counties, as small farms and communities were abandoned for greater opportunities in larger urban centers. From 1960 to 1970, Northern Lake Michigan Coastal counties' combined population loss (-0.6%) continued to lag well behind statewide trends (12% population growth). By the period from 1970 to 1980, population growth in Northern Lake Michigan Coastal counties (13%) had leapt ahead of statewide population change (6.5%), in large part due to the 25% surge in Door County's population alone. From 1980 to 1990, population leveled in the Northern Lake Michigan Coastal counties (3.4% growth, compared to 4% statewide), with Oconto County beginning its continuing trend as the fastest growing Northern Lake Michigan Coastal County. The period from 1990 to 2000 saw increased growth both in Northern Lake Michigan Coastal counties and statewide (10.5 and 9.6%, respectively), with Oconto County growing especially quickly (18%).

Housing

Housing Density. Northern Lake Michigan Coastal counties' combined housing density in 2010 (26.1 housing units per square mile of land) was just over half the state's housing density (48.5 units per square mile) (USCB 2012). Similar to population density, housing density is much higher in Door County (49.7 units per square mile). The remaining Northern Lake Michigan Coastal counties have comparatively low housing densities that range from Marinette County's 21.7 units per square mile to Oconto County's 23.6.

Seasonal Homes. Seasonal and recreational homes are prevalent in Northern Lake Michigan Coastal counties, making up over a quarter (25.3%) of housing stock in 2010, compared to the statewide average of 6.3% (USCB 2012). Of Northern Lake Michigan Coastal counties, tourist haven Door County has the highest portion of its housing in seasonal homes (33.9%), followed by Marinette (30.7%), Oconto (23.9%), and Shawano (9.3%) counties.

Housing Growth. Northern Lake Michigan Coastal counties' housing growth from 1950 to 1960 (28.4%) lagged behind statewide averages (40.4%) but drew closer to statewide housing growth through the 1960s (22.4% in Northern Lake Michigan Coastal counties versus 27.2% statewide) and surpassed it in the 1970s (31.3% in Northern Lake Michigan Coastal counties versus 30.3% statewide). Shawano County has consistently lagged behind statewide averages and the remainder of the Northern Lake Michigan Coastal counties in terms of housing growth. Since 1990, Door and Oconto counties have had considerably higher housing growth than the state and the other Northern Lake Michigan Coastal counties (USCB 2009). Housing development in the Northern Lake Michigan Coastal counties reflects the dynamics of change in the region toward more seasonal housing.

Housing Values. Door County, which has a large concentration of seasonal and recreational homes with associated higher values, is the only Northern Lake Michigan Coastal

County with higher median housing values ($189,200) than the statewide median ($185,400), according to 2005–2009 U.S. census data. Oconto ($142,500) and Shawano ($123,100) have lower home values, while Marinette ($109,800) has the sixth-lowest median housing value among counties statewide (USCB 2012).

The Economy

Northern Lake Michigan Coastal counties support higher levels of natural resource-dependent jobs and tourism jobs compared to the state as a whole, especially in Door County. Unemployment rates are higher than statewide averages, and per capita income and average wages per job are low in the Northern Lake Michigan Coastal counties, indicating a lack of higher paying jobs. However, poverty rates are comparatively low in Northern Lake Michigan Coastal counties, due primarily to the prevalence of an aging population. Property values are tied closely to the local prevalence of tourism and seasonal housing, with values highest in Door County.

Income

Per Capita Income. Total personal income for the Northern Lake Michigan Coastal counties in 2006 was $4.42 billion (2.3% of the state total), divided very evenly among the four counties. The combined per capita income in Northern Lake Michigan Coastal counties in 2006 ($29,661) was lower than the statewide average of $34,405 (Table 15.8) (USBEA 2006). Door County ($37,245) exceeded the statewide average per capita income, setting itself apart from its Northern Lake Michigan Coastal county neighbors across the bay. Oconto County ($28,200), Marinette County ($28,043), and Shawano County ($27,497) had tightly clustered per capita incomes at considerably lower levels.

Household Income. Estimates in 2005 for all four Northern Lake Michigan Coastal counties were lower than the statewide median household income ($47,141) (USCB 2009). Oconto County ($44,670) had the highest median household income among Northern Lake Michigan Coastal counties, while Marinette County ($39,789) had the lowest median household income among Northern Lake Michigan Coastal counties, according to U.S. Census Bureau estimates.

There appear to be some discrepancies in income levels among the four counties (USCB 2012). As an example, per capita income in Door County is higher than the other three counties and the statewide average; however, median household income is lower than the statewide average and Oconto County. The reason for these differences appears to be explained by population age structure differences. Door County has an older population with more retirees resulting in fewer persons per household than the other three counties or statewide. Fewer earners per household in Door County equates to lower median household income even though individual income is higher.

Earnings Per Job. To a greater extent than with either per capita income or household income, 2006 average earnings per job in Northern Lake Michigan Coastal counties ($27,727) were considerably lower than the statewide average ($36,142) (USBEA 2006). Earnings per job in the Northern Lake Michigan Coastal counties ranged from the sixth-lowest figure among Wisconsin counties in Oconto County ($25,106) to moderately low in Marinette County ($30,943).

Unemployment

The Northern Lake Michigan Coastal counties had a combined 2006 unemployment rate of 5.8%, comparatively higher than the state average of 4.7% (Table 15.8). Marinette County (6.4%) had the ecological landscape's highest unemployment rate, followed by Oconto (6.1%), Door (5.4%), and Shawano (5.1%) counties. Unemployment rates have become much higher since 2008 throughout the state.

Poverty

Poverty Rates. The U.S. Census Bureau estimated Northern Lake Michigan Coastal counties' combined 2005 poverty rate at 8.9%, lower than the state as a whole (10.2%) (USCB 2009). Door County (7.3%) had the Northern Lake Michigan Coastal counties' lowest poverty rate, followed by Oconto (8.7%), Shawano (9.6%), and Marinette (9.9%) counties.

Table 15.8. *Economic indicators for the Northern Lake Michigan Coastal counties and Wisconsin.*

	Per capita income[a]	Average earnings per job[a]	Unemployment rate[b]	Poverty rate[c]
Wisconsin	**$34,405**	**$36,142**	**4.7%**	**10.2%**
Door County	$37,245	$26,239	5.4%	7.3%
Marinette County	$28,043	$30,943	6.4%	9.9%
Oconto County	$28,200	$25,106	6.1%	8.7%
Shawano County	$27,497	$26,414	5.1%	9.6%
Northern Lake Michigan Coastal counties	**$29,661**	**$27,727**	**5.8%**	**8.9%**

[a]U.S. Bureau of Economic Analysis, 2006 figures.
[b]U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics, 2006 figures.
[c]U.S. Bureau of the Census, Small Area Income and Poverty Estimates, 2005 figures.

Child Poverty Rates. Compared to the statewide average (14%), 2005 estimates of poverty rates for people under age 18 in Northern Lake Michigan Coastal counties follow similar trends as with overall poverty rates. Child poverty rates are lowest in Door County (10.4%), followed by Oconto (11.1%), Marinette (13.2%), and Shawano (13.5%) (USCB 2009).

Residential Property Values

Average residential property value in the combined Northern Lake Michigan Coastal counties ($134,368 per housing unit) is very close to the statewide average ($134,021) (Table 15.9). However, residential property values are highly variable between Northern Lake Michigan Coastal counties, to an even greater extent than housing values. Door County residential property values ($254,282) are the highest in the state, due largely to the large volume of lakeshore property. Oconto County ($122,951) has residential property values below the state average but above those in Shawano County ($92,346) and Marinette County ($80,454). The Northern Lake Michigan Coastal counties' disparate residential property values reflect the heavy economic influence of seasonal housing and the variable aesthetic values in the region.

Important Economic Sectors

Northern Lake Michigan Coastal counties together provided an estimated 75,774 jobs in 2007, or about 2.1% of the total employment in Wisconsin (Table 15.10). The Tourism-related sector (14.4% of Northern Lake Michigan Coastal counties' employment) is the leading source of employment in Northern Lake Michigan Coastal counties, followed in importance by Manufacturing (non-wood) (13.4%); Government (12.5%); Retail Trade (9.3%); Health Care and Social Service (8.9%); and Agriculture, Fishing, and Hunting (8.4%) (MIG 2009). For definitions of economic sectors, see the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

Importance of economic sectors within the Northern Lake Michigan Coastal counties when compared to the rest of the state was evaluated using an economic base analysis to yield a standard metric called a location quotient (Quintero 2007). Economic base analysis compares the percentage of all jobs in an ecological landscape county approximation for a given economic sector to the percentage of all jobs in the state for the same economic sector. For example, if 10% of the jobs within an ecological landscape county approximation are in the Manufacturing sector and 10% of all jobs in the state are in the Manufacturing sector, then the location quotient would be 1.0, indicating that this ecological landscape county approximation contributes jobs to the manufacturing sector at the same rate as the statewide average. If the location quotient is greater than 1.0, the ecological landscape county approximation is contributing more jobs to the sector than the state average. If the location quotient is less than 1.0, the ecological landscape county approximation is contributing fewer jobs to the sector than the state average.

When compared with the rest of the state, the Northern Lake Michigan Coastal counties had nine sectors of employment with location quotients higher than 1.0 (Figure 15.16; also see Appendix 15.I, "Importance of Economic Sectors within the Northern Lake Michigan Coastal Counties Compared to the Rest of the State"). Of particular local importance are economic sectors dependent on the region's natural resource base. The Agriculture, Fishing and Hunting sector has the highest quotient among sectors in the Northern Lake Michigan Coastal counties, and it had the second-highest portion of those jobs among any ecological landscape county approximation in the state. Agriculture's high location quotient is an indicator of the dependence upon agriculture and natural resources within the Northern Lake Michigan Coastal counties, which have 5.8% of all Agriculture, Fishing and Hunting jobs in the state. However, this would not be a result of traditional agriculture, which is not an important economic activity in the four counties. The high location quotient would more likely be a factor of hunting and sport and commercial fishing in Green Bay and Lake Michigan.

Similarly, the Mining sector's quotient in the Northern Lake Michigan Coastal counties is third-ranked among ecological landscape county approximations statewide, though it contributes relatively few jobs. Forest Products and Processing contributes a small amount of total jobs in Northern Lake Michigan Coastal counties (3,261 jobs), but those jobs represent nearly twice as many jobs as occur proportionally statewide in Forest Products and Processing.

Table 15.9. *Property values for the Northern Lake Michigan Coastal counties and Wisconsin, assessed in 2006 and collected in 2007.*

	Residential property value	Housing units	Residential property value per housing unit
Wisconsin	**$340,217,559,700**	**2,538,538**	**$134,021**
Door	$5,577,684,700	21,935	$254,282
Marinette	$2,287,056,800	28,427	$80,454
Oconto	$2,720,054,500	22,123	$122,951
Shawano	$1,857,176,400	20,111	$92,346
Northern Lake Michigan Coastal counties	**$12,441,972,400**	**92,596**	**$134,368**

Sources (except housing units): Wisconsin Department of Revenue 2006–2007 property tax master file. Housing Units: U. S. Census Bureau estimates for July 1, 2006.

Table 15.10. *Total and percentage of jobs in 2007 in each economic sector within the Northern Lake Michigan Coastal (NLMC) counties. The economic sectors providing the highest percentage of jobs in the NLMC counties are highlighted in blue.*

Industry sector	WI employment	% of WI total	NLMC counties employment	% of NLMC counties total
Agriculture, Fishing & Hunting	110,408	3.1%	6,369	8.4%
Forest Products & Processing	88,089	2.5%	3,261	4.3%
Mining	3,780	0.1%	174	0.2%
Utilities	11,182	0.3%	97	0.1%
Construction	200,794	5.6%	4,622	6.1%
Manufacturing (non-wood)	417,139	11.7%	10,180	13.4%
Wholesale Trade	131,751	3.7%	1,693	2.2%
Retail Trade	320,954	9.0%	7,058	9.3%
Tourism-related	399,054	11.2%	10,888	14.4%
Transportation & Warehousing	108,919	3.1%	2,073	2.7%
Information	57,081	1.6%	850	1.1%
Finance & Insurance	168,412	4.7%	1,720	2.3%
Real Estate, Rental & Leasing	106,215	3.0%	2,154	2.8%
Professional, Science & Tech Services	166,353	4.7%	1,606	2.1%
Management	43,009	1.2%	220	0.3%
Administrative and Support Services	166,405	4.7%	1,197	1.6%
Private Education	57,373	1.6%	671	0.9%
Health Care & Social Services	379,538	10.7%	6,759	8.9%
Other Services	187,939	5.3%	4,750	6.3%
Government	430,767	12.1%	9,434	12.5%
Totals	**3,555,161**		**75,774**	**2.1%**

Source: IMPLAN, © MIG, Inc. (MIG 2009).

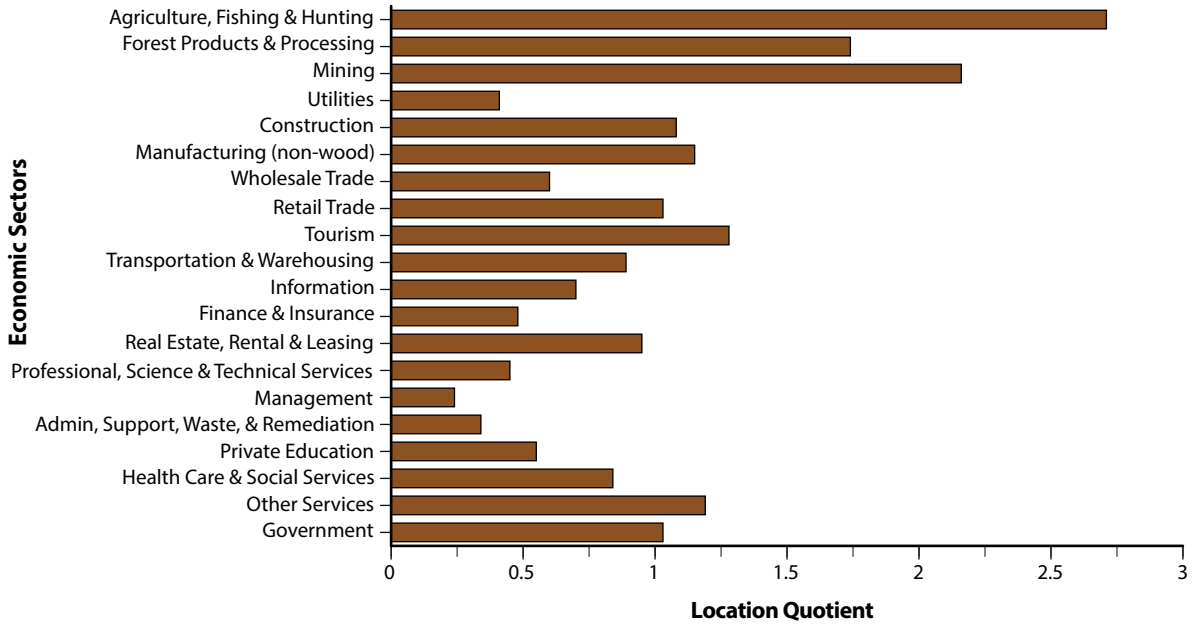


Figure 15.16. *Importance of economic sectors within the Northern Lake Michigan Coastal counties when compared to the rest of the state. If the location quotient is greater than 1.0, the Northern Lake Michigan Coastal counties are contributing more jobs to that economic sector than the state average. If the location quotient is less than 1.0, the Northern Lake Michigan Coastal counties are contributing fewer jobs to that economic sector than the state average.*

Other sectors providing a percentage of jobs in Northern Lake Michigan Coastal counties higher than the state average, listed in order of their relative employment contribution, are Tourism-related, Other Services, Manufacturing (non-wood), Construction, Government, and Retail Trade. These sectors of secondary relative importance can all be tied to the prominence of seasonal housing and recreation-based local economies in Northern Lake Michigan Coastal counties. Higher paying management, finance, and high-tech jobs are underrepresented in Northern Lake Michigan Coastal counties.

The Other Services sector consists primarily of equipment and machinery repairing, promoting or administering religious activities, awarding grants, advocacy, and providing dry-cleaning and laundry services, personal care services, death care services, pet care services, photo finishing services, and temporary parking services. The Tourism-related sector includes relevant subsectors within Retail Trade, Passenger Transportation, and Arts, Entertainment, and Recreation. The Tourism-related sector also includes all Accommodation and Food Services (Marcouiller and Xia 2008). The Forest Products and Processing sector includes sectors in logging, pulp and paper manufacturing, primary wood manufacturing (e.g., sawmills), and secondary wood manufacturing (e.g., furniture manufacturing).

Urban Influence

The U.S. Department of Agriculture's Economic Research Service (USDA ERS) divides counties into 12 groups on a continuum of urban influence, with 1 representing large metropolitan areas, 2 representing smaller metropolitan areas, and the remaining classes from 3 to 12 representing nonmetropolitan (rural) counties increasingly less populated and isolated from urban influence (USDA ERS 2012b). The concept of urban influence assumes that population size, urbanization and access to larger adjacent economies are crucial elements in evaluating potential of local economies. Oconto County, in close proximity to Green Bay in Brown County, is classified as a smaller metropolitan area (class 2). The remaining Northern Lake Michigan Coastal counties are composed of nonmetropolitan counties with moderate degrees of "influence" from adjacent urban areas. Marinette is a class 5 county, while Door and Shawano are class 6 counties.

Economic Types

Based on the assumption that knowledge and understanding of different types of rural economies and their distinctive economic and sociodemographic profiles can aid rural policymaking, the USDA ERS classifies counties in one of six mutually exclusive categories: farming-dependent counties, mining-dependent counties, manufacturing-dependent counties, government-dependent counties, service-dependent counties, and nonspecialized counties (USDA ERS 2012a). Marinette County and Oconto counties were classified as manufacturing-dependent in 2004 according to the Economic Research Service's economic specialization definitions. Door County was classified as service-dependent. Shawano County was classified as nonspecialized.

Policy Types

The USDA ERS also classifies counties according to "policy types" deemed especially relevant to rural development policy (USDA ERS 2012a). Of particular interest in the Northern Lake Michigan Coastal counties are the categories of "nonmetro recreation" and "retirement destination" counties. In 2004, Oconto County was classified as a nonmetro recreation county (rural counties are classified using a combination of factors, including share of employment or share of earnings in recreation-related industries in 1999, share of seasonal or occasional use housing units in 2000, and per capita receipts from motels and hotels in 1997), indicating economic dependence especially upon an influx of tourism and recreational dollars. Door and Marinette counties were classified as both nonmetro recreation counties and retirement destination counties. Retirement destination counties (those in which the number of residents 60 and older grew by 15% or more between 1990 and 2000 due to in-migration) are shaped by an influx of an aging population and have particular needs for health care and services specific to that population.

Integrated Opportunities for Management

Use of natural resources for human needs within the constraints of sustainable ecosystems is an integral part of ecosystem management. Integrating ecological management with socioeconomic programs or activities can result in efficiencies in land use, tax revenues, and private capital. This type of integration can also help generate broader and deeper support for sustainable ecosystem management. However, any human modification or use of natural communities has trade-offs that benefit some species and harm others. Even relatively benign activities such as ecotourism will have impacts on the ecology of an area. Trade-offs caused by management actions need to be carefully weighed when planning management to ensure that some species are not being irreparably harmed. Maintaining healthy, sustainable ecosystems provides many benefits to people and our economy. The development of ecologically sound management plans should save money and sustain natural resources in the long run.

The principles of integrating natural resources and socioeconomic activities are similar across the state. See "Integrated Ecological and Socioeconomic Opportunities" in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book. That section offers suggestions on how and when ecological and socioeconomic needs might be integrated and gives examples of the type of activities that might work together when planning the management of natural resources within a given area.

Appendices

Appendix 15.A. *Watershed water quality summary for the Northern Lake Michigan Coastal Ecological Landscape.*

Watershed number	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
GB01	Suamico & Little Suamico River	109,938	Good; nonpoint urban & agr nutrients are increasing
GB02	Pensaukee River	104,813	Fair to Good; agr NPS > low D.O.; streambank pasturing > erosion/sed/hab; dams > temp
GB03	Lower Oconto River	125,749	Good; three dams on river; some agr NPS
GB04	Little River	134,618	Fair to Good; NPS agr sediment & nutrients persist
GB05	Lower N. Br. Oconto River[b]	249,139	Very Good; many wetlands & lakes; little agr
GB07	Lower Peshtigo River	124,788	Good in the upper reach in this landscape
GB08	Little Peshtigo River	101,397	Fair to Good; Bass Lake treated for excess nutrients
GB09	Middle Inlet & Lake Noquebay	99,571	Good; Lake Noquebay treated for NPS agr impacts
GB13	Wausaukee & Lower Menominee River	119,710	Fair to Poor; industrial & agr pollutants; Area of Concern lower, due to arsenic discharges; many dams
LF05	Duck Creek	97,030	Fair to Poor; urban & agr NPS; sed
TK04	Ahnapee River	86,773	Fair to Good; excess nutrients & PCBs, lack of buffers; agr. NPS > eutrophic lakes & impoundments
TK05	Stony Creek	34,559	Fair to Good; ditching > hab; needs water quality re-evaluation
TK06	Upper Door County	164,464	Fair to V Good; agr ditching of wetlands > sed/hab; flux; lakes mostly shallow/oligo- to mesotrophic; high quality coastal wetland
TK07	Red River & Sturgeon Bay	89,061	Fair to Good; agr NPS > low D.O.; loss of forest/infiltration > Sed/Hab/Flux
WR06	Lower Little Wolf River	98,307	Fair to Good; animal waste & soil erosion problems
WR09	N. Br. & Main Stem Embarrass R.	200,074	V. Good to Fair; trout waters upper; animal waste & soil erosion with low D.O. & impaired fishery, lower
WR10	Pigeon River	74,444	Fair to Good; excess vegetation, turbidity, & habitat degradation
WR11	Mid. & S. Br. Embarrass River	160,004	Good; animal waste & soil erosion problems
WR13	Shioc River	121,447	Good to Fair; flow flux; lacking cropland buffers
WR14	Middle Wolf River	85,619	Good; some NPS animal waste & cropland runoff
WR15	Shawano Lake	45,544	Fair to Good; NPS nutrients > excessive weed growth
WR16	Red River	132,556	V. Good; trout headwaters; NPS agr nutrients a threat
WR17	W. Br. Wolf River	170,312	V. Good to Good; dairy land clearing upper; forest lower

Source: Wisconsin DNR Bureau of Watershed data.

[a]Based on Wisconsin DNR watershed water quality reports.
[b]Only a small fraction of this watershed lies within this ecological landscape, so overall impacts of land uses within the landscape are unlikely to impact water quality within the watershed to any appreciable degree.

Abbreviations:
Agr = Agricultural.
D.O. = Dissolved Oxygen levels are low.
d.s. = Downstream of this ecological landscape.
ERW = Exceptional Resource Water (very good to excellent water quality, with point source discharges).
Flux = Abnormal highs and lows in stream flow fluctuation due to lack of groundwater infiltration, etc., often due to loss of forest cover or creation of excessive impermeable surface.
GW = Groundwater (without modifiers, indicates high nitrates, radon, manganese, or other negative use condition).
Hab = Stream habitat damage.
Hg = Mercury contamination of fish, mainly deposited by coal combustion or sometimes by industry.
Mod = Modification of stream channel, habitat structure, or other aquatic feature.
Muni = Municipal.
NPS = Nonpoint source pollutants, such as farm or parking lot runoff, or septic system leakage.
ORW = Outstanding Resource Water (very good to excellent water quality, with no point source discharges).
P = Phosphorous in excessive amounts, reducing oxygen concentration in a water body.
PAH = Polycyclic aromatic hydrocarbon contamination, often with other toxic substances.
PCBs = Polychlorinated biphenyl industrial pollutants in sediment and aquatic life.
PS = Point source pollutants, such as treated municipal and industrial wastewater.
Sed = Excess sedimentation.
Temp = Elevated temperatures in some stream reaches.
TSI = Trophic state index (indication of impacts of excess nutrients).
Tribs = Streams that are tributary to the stream(s) after which the watershed is named.
u.s. = Upstream of this ecological landscape.
303d = A water listed as impaired under Section 303(d) of the federal Clean Water Act.
> = Yields, creates, or results in (the listed impacts).

Appendix 15.B. *Forest habitat types in the Northern Lake Michigan Coastal Ecological Landscape.*

The forest habitat type classification system (FHTCS) is a site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. This classification system enables the recognition and classification of ecologically similar landscape units (site types) and forest plant communities (vegetation associations).

A forest habitat type is an aggregation of sites (units of land) capable of producing similar late-successional (potential climax) forest plant communities. Each recognizable habitat type represents a relatively narrow segment of environmental variation that is characterized by a certain limited potential for vegetation development. Although at any given time, a habitat type can support a variety of disturbance-induced (seral) plant communities, the ultimate product of succession is presumed to be a similar climax community. Field identification of a habitat type provides a convenient label (habitat type name) for a given site and places that site in the context of a larger group of sites that share similar ecological traits. Forest habitat type groups more broadly combine individual habitat types that have similar ecological potentials.

Individual forest cover types classify current overstory vegetation, but these associations usually encompass a wide range of environmental conditions. In contrast, individual habitat types group ecologically similar sites in terms of vegetation potentials. Management interpretations can be refined and made significantly more accurate by evaluating a stand in terms of the current cover type (current dominant vegetation) plus the habitat type (potential vegetation).

Habitat Types	Description of forest habitat types found in the Northern Lake Michigan Coastal Ecological Landscape.
ATFD	*Acer saccharum-Tsuga canadensis-Fagus grandifolia/Dryopteris spinulosa* Sugar maple-eastern hemlock-American beech/spinulose shield fern
AFAd	*Acer saccharum-Fagus grandifolia/Adiantum pedatum* Sugar maple-American beech/maidenhair fern
AFAl	*Acer saccharum-Fagus grandifolia/Allium tricoccum* Sugar maple-American beech/wild leek
ATAtOn	*Acer saccharum-Tsuga canadensis/Athyrium filix-femina-Onoclea sensibilis* Sugar maple-eastern hemlock/lady fern-sensitive fern
ATFSt	*Acer saccharum-Tsuga canadensis-Fagus grandifolia/Streptopus roseus* Sugar maple-Eastern hemlock-American beech/Rosey twisted stalk
ArAbVc	*Acer rubrum-Abies balsamea/Vaccinium angustifolium-Cornus canadensis* Red maple-balsam fir/blueberry-bunchberry
TMC	*Tsuga canadensis/Maianthemum canadense-Coptis groenlandica* Eastern hemlock/wild lily-of-the-valley-goldthread
AFVb	*Acer saccharum-Fagus grandifolia/Viburnum acerifolium* Sugar maple-American beech/maple-leaved viburnum
AVb	*Acer saccharum/Viburnum acerifolium* Sugar maple/maple-leaved viburnum
ATFPo	*Acer saccharum-Tsuga canadensis-Fagus grandifolia/Polygonatum pubescens* Sugar maple-eastern hemlock-American beech/hairy Solomon's seal
PArVAa-Vb	*Pinus strobus-Acer rubrum/Vaccinium angustifolium-Aralia nudicaulis Viburnum acerifolium* variant White pine-red maple/blueberry-wild sarsaparilla maple-leaved viburnum variant
PArVPo	*Pinus strobus-Acer rubrum/Vaccinium angustifolium-Polygonatum pubescens* White pine-red maple/blueberry-hairy Solomon's seal
TFAa	*Tsuga canadensis-Fagus grandifolia/Aralia nudicaulis* Eastern hemlock-American beech/wild sarsaparilla

Appendix 15.C. *The Natural Heritage Inventory (NHI) table of rare species and natural community occurrences (plus a few miscellaneous features tracked by the NHI program) for the Northern Lake Michigan Coastal (NLMC) Ecological Landscape in November 2009. See the Wisconsin Natural Heritage Working List online for the most current status (Wisconsin DNR 2009b).*

Scientific name (common name)	Lastobs date	EOs[a] in in NLMC	EOs in WI	Percent in NLMC	State rank	Global rank	State status	Federal status
MAMMALS								
Canis lupus (gray wolf)	2008	2	204	1%	S2	G4	SC/FL	LE
Myotis septentrionalis (northern long-eared bat)	1980	2	9	22%	S3	G4	SC/N	
BIRDS[b]								
Accipiter gentilis (Northern Goshawk)	2004	5	141	4%	S2B,S2N	G5	SC/M	
Ammodramus henslowii (Henslow's Sparrow)	1994	2	82	2%	S3B	G4	THR	
Ammodramus leconteii (Le Conte's Sparrow)	1995	2	22	9%	S2S3B	G4	SC/M	
Ardea alba (Great Egret)	2001	1	14	7%	S2B	G5	THR	
Bartramia longicauda (Upland Sandpiper)	1984	2	54	4%	S2B	G5	SC/M	
Botaurus lentiginosus (American Bittern)	1998	2	41	5%	S3B	G4	SC/M	
Bubulcus ibis (Cattle Egret)	1996	1	3	33%	S1B	G5	SC/M	
Bucephala clangula (Common Goldeneye)	1997	2	5	40%	S2B	G5	SC/M	
Buteo lineatus (Red-shouldered Hawk)	2008	19	301	6%	S3S4B,S1N	G5	THR	
Charadrius melodus (Piping Plover)	2008	1	6	17%	S1	G3	END	LE
Chlidonias niger (Black Tern)	1996	3	60	5%	S2B	G4	SC/M	
Coturnicops noveboracensis (Yellow Rail)	1990	3	22	14%	S1B	G4	THR	
Dendroica caerulescens (Black-throated Blue Warbler)[c]	1995	1	27	4%	S3B	G5	SC/M	
Dendroica tigrina (Cape May Warbler)[c]	1999	1	26	4%	S3B	G5	SC/M	
Haliaeetus leucocephalus (Bald Eagle)	2008	38	1286	3%	S4B,S2N	G5	SC/P	
Lanius ludovicianus (Loggerhead Shrike)	1999	2	31	6%	S1B	G4	END	
Larus marinus (Great Black-backed Gull)	1995	1	1	100%	S1B	G5	SC/M	
Nycticorax nycticorax (Black-crowned Night-heron)	1999	9	36	25%	S2B	G5	SC/M	
Pandion haliaetus (Osprey)	2008	33	733	5%	S4B	G5	SC/M	
Podiceps grisegena (Red-necked Grebe)	1993	1	13	8%	S1B	G5	END	
Seiurus motacilla (Louisiana Waterthrush)	1998	1	34	3%	S3B	G5	SC/M	
Spiza americana (Dickcissel)	1999	1	46	2%	S3B	G5	SC/M	
Sterna caspia (Caspian Tern)	1994	2	7	29%	S1B,S2N	G5	END	
Sterna forsteri (Forster's Tern)	2008	5	31	16%	S1B	G5	END	
Sterna hirundo (Common Tern)	1997	3	14	21%	S1B,S2N	G5	END	
Sturnella neglecta (Western Meadowlark)	1997	3	39	8%	S2B	G5	SC/M	
Tyto alba (Barn Owl)	2006	1	29	3%	S1B,S1N	G5	END	
Wilsonia canadensis (Canada Warbler)[c]	2007	1	20	5%	S3B	G5	SC/M	
Wilsonia citrina (Hooded Warbler)[c]	1995	1	32	3%	S2S3B	G5	THR	
HERPTILES								
Acris crepitans (northern cricket frog)	1983	2	102	2%	S1	G5	END	
Diadophis punctatus edwardsii (northern ring-necked snake)	1991	2	23	9%	S3?	G5T5	SC/H	
Emydoidea blandingii (Blanding's turtle)	2008	14	316	4%	S3	G4	THR	
Glyptemys insculpta (wood turtle)	2008	13	262	5%	S2	G4	THR	
Hemidactylium scutatum (four-toed salamander)	2001	3	63	5%	S3	G5	SC/H	
Lithobates catesbeianus (American bullfrog)	2003	3	70	4%	S3	G5	SC/H	
Thamnophis sauritus (eastern ribbonsnake)	2008	1	3	33%	S1	G5	END	
FISHES								
Acipenser fulvescens (lake sturgeon)	1991	13	99	13%	S3	G3G4	SC/H	
Anguilla rostrata (American eel)	1974	1	24	4%	S2	G4	SC/N	

Appendix 15.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NLMC	EOs in WI	Percent in NLMC	State rank	Global rank	State status	Federal status
Clinostomus elongatus (redside dace)	1975	1	96	1%	S3	G3G4	SC/N	
Erimyzon sucetta (lake chubsucker)	1975	1	85	1%	S3	G5	SC/N	
Etheostoma clarum (western sand darter)	1994	1	11	9%	S3	G3	SC/N	
Etheostoma microperca (least darter)	1973	2	83	2%	S3	G5	SC/N	
Fundulus diaphanus (banded killifish)	2008	2	105	2%	S3	G5	SC/N	
Lepomis megalotis (longear sunfish)	1979	3	25	12%	S2	G5	THR	
Lythrurus umbratilis (redfin shiner)	1975	1	37	3%	S2	G5	THR	
Moxostoma valenciennesi (greater redhorse)	2007	5	56	9%	S3	G4	THR	
Notropis anogenus (pugnose shiner)	1971	1	49	2%	S2	G3	THR	
Notropis texanus (weed shiner)	1975	1	45	2%	S3	G5	SC/N	
MUSSELS/CLAMS								
Alasmidonta marginata (elktoe)	1995	4	44	9%	S4	G4	SC/P	
Alasmidonta viridis (slippershell mussel)	1991	5	16	31%	S2	G4G5	THR	
Epioblasma triquetra (snuffbox)[d]	1995	2	5	40%	S1	G3	END	
Pleurobema sintoxia (round pigtoe)	1995	3	50	6%	S3	G4G5	SC/P	
Simpsonaias ambigua (salamander mussel)	1991	5	51	10%	S2S3	G3	THR	
Tritogonia verrucosa (buckhorn)	2005	1	12	8%	S2	G4G5	THR	
MISCELLANEOUS INVERTEBRATES								
Catinella exile (Pleistocene catinella)	1995	2	4	50%	S2	G2	SC/N	
Catinella gelida (a land snail)	1997	1	15	7%	S1S2	G1	SC/N	
Cochlicopa morseana (Appalachian pillar)	1997	6	8	75%	S2	G5	SC/N	
Glyphyalinia rhoadsi (sculpted glyph)	1997	4	6	67%	S2	G5	SC/N	
Glyphyalinia wheatleyi (bright glyph)	1995	1	1	100%	S1	G5	SC/N	
Guppya sterkii (brilliant granule)	1997	1	3	33%	S2S3	G5	SC/N	
Hendersonia occulta (cherrystone drop)	2007	18	53	34%	S3	G4	THR	
Paravitrea multidentata (dentate supercoil)	1998	28	39	72%	S2S3	G5	SC/N	
Striatura ferrea (black striate)	1997	10	14	71%	S2	G5	SC/N	
Vertigo elatior (tapered vertigo)	1997	3	12	25%	S3	G5	SC/N	
Vertigo hubrichti (Midwest Pleistocene vertigo)	1998	25	47	53%	S1	G3	END	
Vertigo morsei (six-whorl vertigo)	1997	2	3	67%	S1	G3	SC/N	
Vertigo nylanderi (deep-throated vertigo)	1997	1	2	50%	S1	G3G4	SC/N	
Vertigo paradoxa (mystery vertigo)	1997	3	6	50%	S1	G4G5Q	SC/N	
Vertigo sp. 2 (Iowa Pleistocene vertigo)	1998	15	21	71%	S1S2	G3Q	SC/N	
Vitrina angelicae (transparent vitrine snail)	1996	2	4	50%	S1	G5	SC/N	
Zoogenetes harpa (boreal top)	1997	1	3	33%	S1	G5	SC/N	
BUTTERFLIES/MOTHS								
Calephelis muticum (swamp metalmark)	2005	4	12	33%	S1	G3	END	
Euphyes bimacula (two-spotted skipper)	1982	1	17	6%	S3	G4	SC/N	
Grammia phyllira (phyllira tiger moth)	1991	2	14	14%	S2	G4	SC/N	
Hesperia leonardus (leonard's skipper)	2000	1	29	3%	S3	G4	SC/N	
Lycaena dorcas (dorcas copper)	2000	2	23	9%	S1S2	G5	SC/N	
Macrochilo bivittata (an owlet moth)	2002	1	8	13%	S3	G3G4	SC/N	
Poanes massasoit (mulberry wing)	1993	2	56	4%	S3	G4	SC/N	
Poanes viator (broad-winged skipper)	1993	2	36	6%	S3	G5	SC/N	
DRAGONFLIES/DAMSELFLIES								
Aeshna clepsydra (mottled darner)	1991	1	9	11%	S2	G4	SC/N	

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Appendix 15.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NLMC	EOs in WI	Percent in NLMC	State rank	Global rank	State status	Federal status
Chromagrion conditum (aurora damselfly)	1991	1	17	6%	S3	G5	SC/N	
Enallagma traviatum (slender bluet)	2000	1	2	50%	S1S2	G5	SC/N	
Epiaeschna heros (swamp darner)	1993	3	4	75%	S1?	G5	SC/N	
Ischnura hastata (citrine forktail)	1991	1	2	50%	S2	G5	SC/N	
Libellula incesta (slaty skimmer)	1990	1	4	25%	S1	G5	SC/N	
Nasiaeschna pentacantha (cyrano darner)	1991	1	14	7%	S3	G5	SC/N	
Ophiogomphus howei (pygmy snaketail)	1999	3	33	9%	S4	G3	THR	
Somatochlora forcipata (forcipate emerald)	1990	1	10	10%	S2	G5	SC/N	
Somatochlora hineana (Hine's emerald)	2006	13	15	87%	S1	G2G3	END	LE
BEETLES								
Cicindela hirticollis rhodensis (beach-dune tiger beetle)	1999	1	8	13%	S2	G5T4	SC/N	
Cicindela patruela huberi (a tiger beetle)	1999	1	84	1%	S3	G3T3	SC/N	
Cymbiodyta acuminata (a water scavenger beetle)	1999	1	7	14%	S3	GNR	SC/N	
Haliplus pantherinus (a crawling water beetle)	1999	1	13	8%	S2S3	GNR	SC/N	
Hydroporus vittatus (a predaceous diving beetle)	1999	3	17	18%	S3	GNR	SC/N	
Laccobius reflexipennis (a predaceous diving beetle)	2000	1	3	33%	S1S2	GNR	SC/N	
Matus bicarinatus (a predaceous diving beetle)	1999	2	5	40%	S2S3	GNR	SC/N	
Stenelmis fuscata (a riffle beetle)	1999	2	5	40%	S3	GNR	SC/N	
MISCELLANEOUS INSECTS/SPIDERS								
Camnula pellucida (clear-winged grasshopper)	2008	4	4	100%	S3?	G5	SC/N	
Isoperla bilineata (a perlodid stonefly)	1996	2	8	25%	S2S3	G5	SC/N	
Isoperla richardsoni (a perlodid stonefly)	1999	1	3	33%	S3	G4	SC/N	
Paracloeodes minutus (a small minnow mayfly)	1992	1	4	25%	S1?	G5	SC/N	
Plauditus cestus (a small minnow mayfly)	2000	1	2	50%	S2	G5	SC/N	
Pseudiron centralis (a flat-headed mayfly)	1999	1	10	10%	S3	G5	SC/N	
Trimerotropis huroniana (Lake Huron locust)	2008	4	4	100%	S1	G2G3	END	
PLANTS								
Acer pensylvanicum (striped maple)	1998	1	1	100%	S1	G5	SC	
Adlumia fungosa (climbing fumitory)	2008	22	29	76%	S2	G4	SC	
Amerorchis rotundifolia (round-leaved orchis)	1985	1	9	11%	S2	G5	THR	
Aplectrum hyemale (putty root)	2001	1	17	6%	S2S3	G5	SC	
Arethusa bulbosa (swamp-pink)	1996	3	96	3%	S3	G4	SC	
Armoracia lacustris (lake-cress)	2008	3	4	75%	S1	G4?	END	
Asclepias ovalifolia (dwarf milkweed)	2004	1	60	2%	S3	G5?	THR	
Asplenium trichomanes (maidenhair spleenwort)	2008	4	27	15%	S3	G5	SC	
Asplenium viride (green spleenwort)	1999	1	2	50%	S1	G4	END	
Astragalus neglectus (Cooper's milkvetch)	2000	1	3	33%	S1	G4	END	
Bartonia paniculata (Twining screwstem)	2003	1	4	25%	S1	G5	SC	
Bartonia virginica (yellow screwstem)	2003	2	81	2%	S3	G5	SC	
Botrychium campestre (prairie dunewort)	2005	1	4	25%	S1	G3G4	END	
Botrychium lunaria (moonwort grape-fern)	1997	4	6	67%	S1S2	G5	END	
Botrychium minganense (Mingan's moonwort)	1998	1	17	6%	S2	G4	SC	
Botrychium oneidense (blunt-lobe grape-fern)	1980	1	35	3%	S2	G4Q	SC	
Botrychium spathulatum (spoon-leaf moonwort)	1982	1	1	100%	S1	G3	SC	
Cakile lacustris (American sea-rocket)	2000	16	40	40%	S3	G5	SC	
Calamagrostis stricta (slim-stem small-reedgrass)	2000	9	34	26%	S3	G5	SC	
Calamintha arkansana (low calamint)	2000	16	18	89%	S2	G5	SC	

Appendix 15.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NLMC	EOs in WI	Percent in NLMC	State rank	Global rank	State status	Federal status
Calamovilfa longifolia var. *magna* (sand reedgrass)	2000	3	10	30%	S2	G5T3T5	THR	
Calypso bulbosa (fairy slipper)	1973	1	34	3%	S3	G5	THR	
Cardamine pratensis (cuckooflower)	2000	5	42	12%	S3	G5	SC	
Carex capillaris (hair-like sedge)	2000	6	9	67%	S2	G5	SC	
Carex concinna (beautiful sedge)	1999	4	5	80%	S1	G4G5	THR	
Carex crawei (Crawe's sedge)	2000	14	24	58%	S3	G5	SC	
Carex exilis (coast sedge)	1998	3	5	60%	S1	G5	THR	
Carex formosa (handsome sedge)	2000	1	16	6%	S2	G4	THR	
Carex garberi (elk sedge)	2005	9	9	100%	S2	G5	THR	
Carex gynocrates (northern bog sedge)	2008	6	31	19%	S3	G5	SC	
Carex livida var. *radicaulis* (livid sedge)	2000	6	21	29%	S2	G5T5	SC	
Carex platyphylla (broad-leaf sedge)	2008	15	15	100%	S2	G5	SC	
Carex prasina (drooping sedge)	1999	1	31	3%	S3	G4	THR	
Carex richardsonii (Richardson sedge)	2000	2	24	8%	S2	G4	SC	
Carex sychnocephala (many-headed sedge)	2000	2	15	13%	S2	G4	SC	
Carex tenuiflora (sparse-flowered sedge)	2008	2	84	2%	S3	G5	SC	
Carex vaginata (sheathed sedge)	2000	2	35	6%	S3	G5	SC	
Cirsium pitcheri (dune thistle)	2008	6	9	67%	S2	G3	THR	LT
Corallorhiza odontorhiza (autumn coral-root)	2006	3	36	8%	S3	G5	SC	
Cypripedium arietinum (ram's-head lady's-slipper)	2002	6	21	29%	S2	G3	THR	
Cypripedium parviflorum var. *makasin* (northern yellow lady's-slipper)	2008	10	78	13%	S3	G5T4Q	SC	
Cypripedium reginae (showy lady's-slipper)	2008	16	99	16%	S3	G4	SC	
Deschampsia cespitosa (tufted hairgrass)	2000	6	17	35%	S2	G5	SC	
Deschampsia flexuosa (crinkled hairgrass)	2007	8	44	18%	S3	G5	SC	
Draba arabisans (rock whitlow-grass)	2008	7	9	78%	S2	G4	SC	
Draba lanceolata (lanceolate whitlow-cress)	1994	1	1	100%	S1	G3G5Q	END	
Drosera linearis (slenderleaf sundew)	1995	1	5	20%	S1	G4	THR	
Dryopteris expansa (spreading woodfern)	1997	1	13	8%	S2	G5	SC	
Dryopteris filix-mas (male fern)	1977	1	3	33%	S1	G5	SC	
Eleocharis olivacea (capitate spikerush)	2003	8	12	67%	S2	G5	SC	
Eleocharis quinqueflora (few-flower spikerush)	2008	8	18	44%	S2	G5	SC	
Eleocharis wolfii (wolf spikerush)	2003	1	2	50%	S1	G3G4	END	
Elymus lanceolatus ssp. *psammophilus* (thickspike)	2000	9	12	75%	S2	G5T3	THR	
Epilobium palustre (marsh willow-herb)	1983	1	37	3%	S3	G5	SC	
Epilobium strictum (downy willow-herb)	2003	1	22	5%	S2S3	G5?	SC	
Equisetum palustre (marsh horsetail)	2003	2	21	10%	S2	G5	SC	
Equisetum variegatum (variegated horsetail)	2003	26	47	55%	S3	G5	SC	
Eriophorum alpinum (alpine cotton-grass)	2008	4	25	16%	S2	G5	SC	
Euphorbia polygonifolia (seaside spurge)	2002	12	20	60%	S2	G5?	SC	
Festuca occidentalis (western fescue)	2008	4	4	100%	S1	G5	THR	
Galium palustre (marsh bedstraw)	1995	3	4	75%	S1	G5	SC	
Gentianopsis procera (lesser fringed gentian)	2000	14	66	21%	S3	G5	SC	
Geocaulon lividum (northern comandra)	1999	2	2	100%	S1	G5	END	
Gymnocarpium robertianum (limestone oak fern)	1979	1	8	13%	S2	G5	SC	
Iris lacustris (dwarf lake iris)	2006	38	41	93%	S3	G3	THR	LT
Leucophysalis grandiflora (large-flowered ground-cherry)	2001	1	3	33%	S1	G4?	SC	
Malaxis monophyllos var. *brachypoda* (white adder's-mouth)	2008	9	48	19%	S3	G4Q	SC	

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Appendix 15.C, *continued.*

Scientific name common name)	Lastobs date	EOs[a] in in NLMC	EOs in WI	Percent in NLMC	State rank	Global rank	State status	Federal status
Medeola virginiana (Indian cucumber-root)	2003	8	42	19%	S3	G5	SC	
Myriophyllum farwellii (Farwell's water-milfoil)	1977	1	60	2%	S3	G5	SC	
Orobanche uniflora (one-flowered broomrape)	2001	5	30	17%	S3	G5	SC	
Osmorhiza chilensis (Chilean sweet cicely)	1999	4	33	12%	S3	G5	SC	
Parnassia parviflora (Small-flower grass-of-parnassus)	1985	1	1	100%	S1	G4	END	
Petasites sagittatus (arrow-leaved sweet-coltsfoot)	2001	1	31	3%	S3	G5	THR	
Platanthera dilatata (leafy white orchis)	1999	3	31	10%	S3	G5	SC	
Platanthera flava var. *herbiola* (pale green orchid)	2003	2	20	10%	S2	G4T4Q	THR	
Platanthera hookeri (Hooker's orchis)	1998	3	20	15%	S2S3	G4	SC	
Platanthera orbiculata (large roundleaf orchid)	2000	3	78	4%	S3	G5	SC	
Polystichum acrostichoides (Christmas fern)	1975	1	13	8%	S2	G5	SC	
Primula mistassinica (bird's-eye primrose)	2008	11	42	26%	S3	G5	SC	
Ptelea trifoliata (wafer-ash)	2004	1	14	7%	S2	G5	SC	
Pterospora andromedea (giant pinedrops)	1999	2	3	67%	S1	G5	END	
Ranunculus cymbalaria (seaside crowfoot)	1991	1	15	7%	S2	G5	THR	
Rhynchospora fusca (brown beakrush)	1999	1	21	5%	S2	G4G5	SC	
Ribes hudsonianum (northern black currant)	1999	2	76	3%	S3	G5	SC	
Scirpus cespitosus (tufted bulrush)	1999	6	20	30%	S2	G5	THR	
Selaginella selaginoides (low spike-moss)	1994	1	1	100%	S1	G5	END	
Senecio congestus (marsh ragwort)	2008	1	3	33%	S1	G5	SC	
Solidago ohioensis (Ohio goldenrod)	2000	11	74	15%	S3	G4	SC	
Solidago simplex var. *gillmanii* (dune goldenrod)	2000	15	16	94%	S2	G5T3?	THR	
Spiranthes lucida (shining lady's-tresses)	2001	1	1	100%	S1	G5	SC	
Tanacetum huronense (Lake Huron tansy)	1979	1	1	100%	S1	G5T4T5	END	
Thalictrum revolutum (waxleaf meadowrue)	1981	1	13	8%	S2	G5	SC	
Tiarella cordifolia (heart-leaved foam-flower)	1994	1	3	33%	S1	G5	END	
Tofieldia glutinosa (sticky false-asphodel)	1999	3	23	13%	S2S3	G4G5	THR	
Triglochin maritima (common bog arrow-grass)	2008	8	59	14%	S3	G5	SC	
Triglochin palustris (slender bog arrow-grass)	2000	8	36	22%	S3	G5	SC	
Trillium nivale (snow trillium)	2000	2	34	6%	S3	G4	THR	
Trisetum melicoides (purple false oats)	1997	2	2	100%	S1	G4	END	
Utricularia geminiscapa (hidden-fruited bladderwort)	1972	1	95	1%	S3	G4G5	SC	
Viburnum nudum var. *cassinoides* (northern wild-raisin)	2003	4	6	67%	S2	G5T5	SC	
Viola rostrata (long-spur violet)	2008	15	22	68%	S2S3	G5	SC	
Zigadenus elegans var. *glaucus* (white camas)	2008	1	4	25%	S2S3	G5T4T5	SC	
COMMUNITIES								
Alder Thicket	2004	5	106	5%	S4	G4	NA	
Alvar	2000	1	2	50%	S1	G3	NA	
Boreal Forest	2000	9	36	25%	S2	G3?	NA	
Boreal Rich Fen	2007	10	18	56%	S2	G4G5	NA	
Emergent Marsh	2007	16	272	6%	S4	G4	NA	
Floodplain Forest	2007	3	182	2%	S3	G3?	NA	
Forested Seep	1998	1	15	7%	S2	GNR	NA	
Great Lakes Alkaline Rockshore	2000	10	10	100%	S2	G3	NA	
Great Lakes Barrens	1998	1	2	50%	S1	G2	NA	
Great Lakes Beach	1999	12	24	50%	S2	G3	NA	
Great Lakes Dune	2001	6	15	40%	S2	G3	NA	
Great Lakes Ridge and Swale	2001	4	7	57%	S2	G3	NA	
Hardwood Swamp	2007	5	53	9%	S3	G4	NA	

Appendix 15.C, *continued.*

Scientific name common name)	Lastobs date	EOs[a] in in NLMC	EOs in WI	Percent in NLMC	State rank	Global rank	State status	Federal status
Interdunal Wetland	1988	1	6	17%	S1	G2?	NA	
Lake—Deep, Soft, Seepage	2004	1	49	2%	S3	GNR	NA	
Lake—Shallow, Hard, Drainage	2000	4	35	11%	SU	GNR	NA	
Lake—Shallow, Hard, Seepage	1998	3	52	6%	SU	GNR	NA	
Lake—Shallow, Soft, Seepage	1981	1	87	1%	S4	GNR	NA	
Lake—Shallow, Very Hard, Drainage (Marl)	1988	1	1	100%	S2	GNR	NA	
Lake—Soft Bog	1981	1	52	2%	S4	GNR	NA	
Moist Cliff	2000	7	176	4%	S4	GNR	NA	
Northern Dry Forest	1999	2	63	3%	S3	G3?	NA	
Northern Dry-mesic Forest	2007	15	284	5%	S3	G4	NA	
Northern Mesic Forest	2007	33	383	9%	S4	G4	NA	
Northern Sedge Meadow	2007	15	231	6%	S3	G4	NA	
Northern Wet Forest	1982	9	322	3%	S4	G4	NA	
Northern Wet-mesic Forest	2007	28	243	12%	S3S4	G3?	NA	
Oak Woodland	2001	1	10	10%	S1?	GNR	NA	
Open Bog	1981	5	173	3%	S4	G5	NA	
Riverine Mud Flat	2003	1	1	100%	SU	GNR	NA	
Shore Fen	2000	1	11	9%	S2	GNR	NA	
Shrub-carr	1999	2	143	1%	S4	G5	NA	
Southern Dry-mesic Forest	2003	2	293	1%	S3	G4	NA	
Southern Hardwood Swamp	2007	4	30	13%	S2	G4?	NA	
Southern Mesic Forest	2000	7	221	3%	S3	G3?	NA	
Southern Sedge Meadow	2003	3	182	2%	S3	G4?	NA	
Spring Pond	1981	2	69	3%	S3	GNR	NA	
Springs and Spring Runs, Hard	1976	2	71	3%	S4	GNR	NA	
Stream—Fast, Hard, Cold	1981	1	98	1%	S4	GNR	NA	
Talus Forest	1999	1	6	17%	S1	G4G5	NA	
Wet-mesic Prairie	1971	1	81	1%	S2	G2	NA	
OTHER ELEMENTS								
Bat hibernaculum	1986	2	43	5%	S3	GNR	SC	
Bird rookery	1996	1	54	2%	SU	G5	SC	

[a]An element occurrence is an area of land and/or water in which a rare species or natural community is, or was, present. Element occurrences must meet strict criteria that is used by an international network of Heritage programs and coordinated by NatureServe.
[b]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.
[c]The American Ornithologist's Union lists these warbler names as Black-throated blue Warbler (*Setophaga caerulescens*), Canada Warbler (*Cardellina canadensis*), Cape May Warbler (*Setophaga tigrina*), and Hooded Warbler (*Setophaga citrina*).
[d]The snuffbox mussel (*Epioblasma triquetra*) was listed as U.S. Endangered in 2012.

STATUS AND RANKING DEFINITIONS

U.S. Status—Current federal protection status designated by the Office of Endangered Species, U.S. Fish and Wildlife Service, indicating the biological status of a species in Wisconsin:

LE = listed endangered.
LT = listed threatened.
PE = proposed as endangered.
NEP = nonessential experimental population.
C = candidate for future listing.
CH = critical habitat.

State Status—Protection category designated by the Wisconsin DNR:

END = Endangered. Endangered species means any species whose continued existence as a viable component of this state's wild animals or wild plants is determined by the Wisconsin DNR to be in jeopardy on the basis of scientific evidence.
THR = Threatened species means any species of wild animals or wild plants that appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.
SC = Special Concern. Special Concern species are those species about which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Appendix 15.C, *continued.*

Wisconsin DNR and federal regulations regarding Special Concern species range from full protection to no protection. The current categories and their respective level of protection are as follows:
SC/P = fully protected;
SC/N = no laws regulating use, possession, or harvesting;
SC/H = take regulated by establishment of open closed seasons;
SC/FL = federally protected as endangered or threatened but not so designated by Wisconsin DNR;
SC/M = fully protected by federal and state laws under the Migratory Bird Act.

Global Element Ranks:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state or physiographic region) or because of other factor(s) making it vulnerable to extinction throughout its range; typically 21-100 occurrences.
G4 = Uncommon but not rare (although it may be quite rare in parts of its range, especially at the periphery) and usually widespread. Typically > 100 occurrences.
G5 = Common, widespread, and abundant (although it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.
GH = Known only from historical occurrence throughout its range, with the expectation that it may be rediscovered.
GNR = Not ranked. Replaced G? rank and some GU ranks.
GU = Currently unrankable due to lack of data or substantially conflicting data on status or trends. Possibly in peril range-wide, but status is uncertain.
GX = Presumed to be extinct throughout its range (e.g., Passenger pigeon) with virtually no likelihood that it will be rediscovered.

Species with a questionable taxonomic assignment are given a "Q" after the global rank. Subspecies and varieties are given subranks composed of the letter "T" plus a number or letter. The definition of the second character of the subrank parallels that of the full global rank. (Examples: a rare subspecies of a rare species is ranked G1T1; a rare subspecies of a common species is ranked G5T1.)

State Element Ranks:

S1 = Critically imperiled in Wisconsin because of extreme rarity, typically 5 or fewer occurrences and/or very few (<1,000) remaining individuals or acres, or due to some factor(s) making it especially vulnerable to extirpation from the state.
S2 = Imperiled in Wisconsin because of rarity, typically 6–20 occurrences and/or few (1,000– 3,000) remaining individuals or acres, or due to some factor(s) making it very vulnerable to extirpation from the state.
S3 = Rare or uncommon in Wisconsin, typically 21–100 occurrences and/or 3,000–10,000 individuals.
S4 = Apparently secure in Wisconsin, usually with > 100 occurrences and > 10,000 individuals.
S5 = Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.
SNA = Accidental, nonnative, reported but unconfirmed, or falsely reported.
SH = Of historical occurrence in Wisconsin, perhaps having not been verified in the past 20 years and suspected to be still extant. Naturally, an element would become SH without such a 20-year delay if the only known occurrence were destroyed or if it had been extensively and unsuccessfully looked for.
SNR = Not Ranked; a state rank has not yet been assessed.
SU = Currently unrankable. Possibly in peril in the state, but status is uncertain due to lack of information or substantially conflicting data on status or trends.
SX = Apparently extirpated from the state.

State ranking of long-distance migrant animals:

Ranking long distance aerial migrant animals presents special problems relating to the fact that their nonbreeding status (rank) may be quite different from their breeding status, if any, in Wisconsin. In other words, the conservation needs of these taxa may vary between seasons. In order to present a less ambiguous picture of a migrant's status, it is necessary to specify whether the rank refers to the breeding (B) or nonbreeding (N) status of the taxon in question. (e.g. S2B,S5N).

Appendix 15.D. *Number of species with special designations documented within the Northern Lake Michigan Coastal Ecological Landscape.*

Listing status	Taxa					Total fauna	Total plants	Total listed
	Mammals	Birds	Herptiles	Fishes	Invertebrates			
U.S. Endangered	1	1	0	0	1	3	0	3
U.S. Threatened	0	0	0	0	0	0	2	2
U.S. Candidate	0	0	0	0	0	0	0	0
Wisconsin Endangered	0	7	2	0	5	14	14	28
Wisconsin Threatened	0	5	2	4	5	16	22	38
Wisconsin Special Concern	2	17	3	8	46	76	66	142
Natural Heritage Inventory total	**2**	**29**	**7**	**12**	**56**	**106**	**102**	**208**

Note: Wisconsin-listed species always include federally listed species (although they may not be the same designation); therefore, federally listed species are not included in the total.

Appendix 15.E. *Species of Greatest Conservation Need (SGCN) found in the Northern Lake Michigan Coastal Ecological Landscape.*

These SGCNs have a high or moderate probability of being found in this ecological landscape and use habitats that have the best chance for management here. Data are from the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b) and Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 of this book ("Supporting Materials"). For more complete and/or detailed information, please see the Wisconsin Wildlife Action Plan. The Wildlife Action Plan is meant to be dynamic and will be periodically updated to reflect new information; the next update is planned for 2013–2015.

Only SGCNs highly or moderately (H = high association, M = moderate association) associated with specific community types or other habitat types and which have a high or moderate probability of occurring in the ecological landscape are included here (SGCNs with a low affinity with a community type or other habitat type and with low probability of being associated with this ecological landscape were excluded). Only community types designated as "Major" or "Important" management opportunities for the ecological landscape are shown.


Lesser scaup. Photo by Herbert Lange.

	MAJOR													IMPORTANT															
	Boreal Rich Fen	Dry Cliff	Emergent Marsh	Great Lakes Beach	Great Lakes Dune	Great Lakes Ridge and Swale	Lake Michigan	Northern Mesic Forest	Northern Sedge Meadow	Northern Wet-mesic Forest	Shrub Carr	Warmwater Rivers	Warmwater Streams	Boreal Forest	Cedar Glade	Coolwater Streams	Ephemeral Pond	Floodplain Forest	Impoundments/Reservoirs	Inland Lakes	Interdunal Wetland	Moist Cliff	Northern Dry Forest	Northern Dry-mesic Forest	Northern Hardwood Swamp	Northern Wet Forest	Shore Fen	Southern Sedge Meadow	Submergent Marsh	Surrogate Grasslands
Species that are Significantly Associated with the Northern Lake Michigan Coastal Ecological Landscape																													
MAMMALS																													
Northern flying squirrel						M		H		H				H				M					M	H	M	H			
Water shrew								M		H			M	H		H		M		M					H	H			
BIRDS[a]																													
American Golden Plover			M																M										M
American Woodcock								M			H														M				
Bald Eagle							M					H							H	H								M	
Black Tern			H						M										M	M								M	
Black-billed Cuckoo						M		M			H							M											
Black-throated Blue Warbler								H																M					
Blue-winged Teal			H						M									M	M	M							M	M	M
Bobolink									H																		M		H
Brown Thrasher						M																							M
Canada Warbler	M					H		M		H				H										M	H	M			
Canvasback												H							M	M								H	
Caspian Tern				H			H																						
Common Tern			M	H			H																						
Dunlin			M	H								M							M										
Eastern Meadowlark																											M		H
Field Sparrow															H														M
Forster's Tern			H																M									M	
Great Egret			H									M						M										M	
Horned Grebe							H																						

Appendix 15.E, *continued.*


Wood turtle. Photo by Wisconsin DNR staff.

	MAJOR													IMPORTANT																
	Boreal Rich Fen	Dry Cliff	Emergent Marsh	Great Lakes Beach	Great Lakes Dune	Great Lakes Ridge and Swale	Lake Michigan	Northern Mesic Forest	Northern Sedge Meadow	Northern Wet-mesic Forest	Shrub Carr	Warmwater Rivers	Warmwater Streams	Boreal Forest	Cedar Glade	Coolwater Streams	Ephemeral Pond	Floodplain Forest	Impoundments/Reservoirs	Inland Lakes	Interdunal Wetland	Moist Cliff	Northern Dry Forest	Northern Dry-mesic Forest	Northern Hardwood Swamp	Northern Wet Forest	Shore Fen	Southern Sedge Meadow	Submergent Marsh	Surrogate Grasslands
Hudsonian Godwit			H																											
Least Flycatcher						M		H						M				M					M	M	M					
Lesser Scaup												M							M	M									H	
Northern Goshawk								H						M										M						
Northern Harrier									H																			M		H
Olive-sided Flycatcher						M				M				M												H				
Osprey												H							H	H										
Peregrine Falcon		H																												
Red-headed Woodpecker																		M												
Red-shouldered Hawk								M									H	H						M						
Short-billed Dowitcher			H																M											
Upland Sandpiper																														H
Veery						M		M			H			H				M						M	H	M				
Vesper Sparrow																														
Whimbrel			M	H																										
Whip-poor-will																							M	M						
Willow Flycatcher											H																	M		M
Wood Thrush						M		M										M												
HERPTILES																														
Mink frog	M		H						H		M	H	H			H	M		H	H									H	
Mudpuppy							H					H							H	H										
Wood turtle								H	M	M	H	H	H			H	M	H							M	M		M	H	
FISH																														
Banded killifish							H													M										
Lake sturgeon							H					H							H	H										
Shoal chub (speckled chub)												H																		
Species that are Moderately Associated with the Northern Lake Michigan Coastal Ecological Landscape																														
MAMMALS																														
Eastern red bat	M		M					M	M	M	M	M	M	M		H	H	M		M			M	M	M	M	M	M	M	
Gray wolf								H		H	M			H				M					M	H	M	H				
Hoary bat	M		M					M	M	M	M	M	M	M		H	H	M		M			M	M	M	M	M	M	M	
Northern long-eared bat	M		M					M	M		M	M	M			H	H	M		M			M	M	M			M	M	
Silver-haired bat	M		M					M	M	M	M	M	M	M		H	H	M		M			M	M	M	M	M	M	M	
Woodland jumping mouse								H		M				M			M	M							M	M				

Continued on next page

Appendix 15.E, *continued.*


Rusty blackbird. Photo by Dave Menke, USFWS.

	MAJOR													IMPORTANT																				
	Boreal Rich Fen	Dry Cliff	Emergent Marsh	Great Lakes Beach	Great Lakes Dune	Great Lakes Ridge and Swale	Lake Michigan	Northern Mesic Forest	Northern Sedge Meadow	Northern Wet-mesic Forest	Shrub Carr	Warmwater Rivers	Warmwater Streams	Boreal Forest	Cedar Glade	Coolwater Streams	Ephemeral Pond	Floodplain Forest	Impoundments/Reservoirs	Inland Lakes	Interdunal Wetland	Moist Cliff	Northern Dry Forest	Northern Dry-mesic Forest	Northern Hardwood Swamp	Northern Wet Forest	Shore Fen	Southern Sedge Meadow	Submergent Marsh	Surrogate Grasslands
BIRDS																																	
American Bittern			H						H																			M				
Blue-winged Warbler											M							M														
Buff-breasted Sandpiper			M																													M
Dickcissel																																H
Golden-winged Warbler								M			H												M	M	M	M						
Grasshopper Sparrow																																H
Henslow›s Sparrow																																H
Loggerhead Shrike																																H
Marbled Godwit			H																													M
Piping Plover				H	H																											
Rusty Blackbird			M			M					M						M	H														
Snowy Egret			H																											M		
Solitary Sandpiper			H			M							M			M	H	H			M											
Western Meadowlark																																H
Yellow Rail									H																		M					
Yellow-billed Cuckoo											M							H														
HERPTILES																																	
Four-toed salamander			H			H		H	M	H	H			M		M	H	H							M	M	H	M				
Blanding's turtle			H						M		M	M	M		M	M	H	M	H	H								M	H			
Pickerel frog			H					M	H	M	M	H	H			H	H	M	H	M						M	M	H	H			
FISH																																	
Greater redhorse							M					M	H						M	M												
Longear sunfish												M	M							M												
Pugnose shiner													M							M												
Redfin shiner												H	M						M													
Western sand darter												M																					

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 15.F. *Natural communities[a] for which there are management opportunities in the Northern Lake Michigan Coastal Ecological Landscape.*

Major opportunity[b]	Important opportunity[c]	Present[d]
Northern Mesic Forest	Boreal Forest	Southern Mesic Forest
Northern Wet-Mesic Forest	Northern Dry Forest	
	Northern Dry-Mesic Forest	Great Lakes Barrens
Shrub Carr	Northern Wet Forest	
	Northern Hardwood Swamp	Alder Thicket
Northern Sedge Meadow		
	Floodplain Forest	Open Bog
Boreal Rich Fen		Emergent Marsh – Wild Rice
Emergent Marsh	Cedar Glade	
		Bedrock Glade
Dry Cliff (Curtis's Exposed Cliff)	Southern Sedge Meadow	
Great Lakes Alkaline Rockshore	Surrogate Grasslands	Coldwater Stream
Great Lakes Dune		
Great Lakes Beach	Shore Fen	
Great Lakes Ridge and Swale	Submergent Marsh	
	Interdunal Wetland	
Lake Michigan	Ephemeral Pond	
Warmwater River		
Warmwater Stream	Clay Seepage Bluff	
	Alvar	
	Moist Cliff (Curtis's Shaded Cliff)	
	Coolwater Stream	
	Impoundment/Reservoir	
	Inland Lake	

[a]See Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," for definitions of natural community types. Also see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape" in Part 3 of the book for an explanation on how the information in this table can be used.

[b]Major opportunity – Relatively abundant, represented by multiple significant occurrences, or ecological landscape is appropriate for major restoration activities.

[c]Important opportunity – Less abundant but represented by one to several significant occurrences or type is restricted to one or a few ecological landscapes.

[d]Present – Uncommon or rare, with no good occurrences documented. Better opportunities are known to exist in other ecological landscapes, or opportunities have not been adequately evaluated.

Appendix 15.G. *Public conservation lands in the Northern Lake Michigan Coastal Ecological Landscape, 2005.*

Property name	Size (acres)[a]
STATE	
Baileys Harbor Boreal Forest State Natural Area	360
Bloch Oxbow State Natural Area	560
Gardner Swamp State Wildlife Area	1,115
Green Bay West Shores State Wildlife Area[b]	5,830
Lake Noquebay State Wildlife Area	1,240
Mud Lake State Wildlife Area - Door County	2,090
Navarino State Wildlife Area[b]	180
Newport State Park	2,420
North Branch Beaver Creek State Fishery Area[b]	660
Peninsula State Park	3,660
Potawatomi State Park	1,170
Rock Island State Park	825
Whitefish Dunes State Park	865
Miscellaneous lands[c]	2,970
FEDERAL	
Waterfowl Production Areas	195
COUNTY FOREST[d]	
Marinette County Forest[b]	9,000
Oconto County Forest[b]	13,930
TOTAL	**47,070**

Source: Wisconsin Land Legacy Report (Wisconsin DNR 2006c).

[a]Actual acres owned in this ecological landscape.

[b]This property also falls within adjacent ecological landscape(s).

[c]Includes public access sites, fish hatcheries, fire towers, streambank and nonpoint easements, lands acquired under statewide wildlife, fishery, forestry, and natural area programs, Board of Commissioners of Public Lands holdings, small properties under 100 acres, and properties with fewer than 100 acres within this ecological landscape.

[d]Locations and sizes of county-owned parcels enrolled in the Forest Crop Law are presented here. Information on locations and sizes of other county and local parks in this ecological landscape is not readily available and is not included here, except for some very large properties.

Appendix 15.H. *Land Legacy Places in the Northern Lake Michigan Coastal Ecological Landscape.*

The *Wisconsin Land Legacy Report* (Wisconsin DNR 2006c) identified 23 places in the Northern Lake Michigan Coastal Ecological Landscape that merit conservation action based upon a combination of ecological significance and recreational potential.

Code	Place name	Size	Protection initiated	Protection remaining	Conservation significance[a]	Recreation potential[b]
CI	Chambers Island	Small	Limited	Substantial	xxx	x
CS	Colonial Waterbird Nesting Islands	Small	Substantial	Limited	xxx	x
DP	Door Peninsula Hardwood Swamps	Medium	Limited	Moderate	xxx	x
EH	Eagle Harbor to Toft Point Corridor	Small	Limited	Moderate	xxxxx	x
GT	Grand Traverse Islands	Medium	Moderate	Moderate	xxxxx	xx
KL	Kangaroo Lake	Small	Moderate	Limited	xxxx	xx
LB	Lower Wolf River Bottomlands	Large	Substantial	Moderate	xxxxx	xxxxx
MR	Menominee River	Large	Limited	Substantial	xxxx	xxx
ME	Mink River Estuary – Newport State Park - Europe Lake	Medium	Substantial	Limited	xxxxx	xx
NE	Niagara Escarpment	Large	Moderate	Substantial	xxxxx	xxxxx
NQ	Noquebay Conifer Swamp	Small	Limited	Substantial	xxx	x
NY	North Bay to Bailey's Harbor	Medium	Substantial	Moderate	xxxxx	x
OR	Oconto River	Large	Moderate	Moderate	xxxx	xxx
OM	Oconto River Marsh	Small	Substantial	Limited	xxx	xx
PS	Peninsula State Park	Small	Substantial	Limited	xxx	xxxxx
PJ	Peninsula State Park to Jacksonport Corridor	Small	Limited	Substantial	xxx	xxxx
PH	Peshtigo Harbor Marsh	Small	Substantial	Limited	xxxxx	x
PE	Peshtigo River	Large	Moderate	Moderate	xx	xxxx
RD	Red River	Medium	Limited	Substantial	xxx	xxx
SB	Seagull Bar	Small	Substantial	Limited	xxx	x
SS	Shivering Sands	Medium	Moderate	Limited	xxxxx	xx
SU	Suamico, Little Suamico, and Pensaukee Rivers	Medium	Limited	Substantial	xxx	xxx
WS	West Shore Green Bay Wetlands	Medium	Substantial	Limited	xxxx	xxx

[a]Conservation significance (see the *Wisconsin Land Legacy Report* (Wisconsin DNR 2006c), p. 43, for detailed discussion.

- xxxxx Possesses outstanding ecological qualities, is large enough to meet the needs of critical components, and/or harbors globally or continentally significant resources. Restoration, if needed, has a high likelihood of success.
- xxxx Possesses excellent ecological qualities, is large enough to meet the needs of most critical components, and/or harbors continentally or Great Lakes regionally significant resources. Restoration has a high likelihood of success.
- xxx Possesses very good ecological qualities, is large enough to meet the needs of some critical components, and/or harbors statewide significant resources. Restoration will typically be important and has a good likelihood of success.
- xx Possesses good ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors statewide or ecological landscape significant resources. Restoration is likely needed and has a good chance of success.
- x Possesses good to average ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors ecological landscape significant resources. Restoration is needed and has a reasonable chance of success.

[b]Recreation potential (see the *Wisconsin Land Legacy Report*, p. 43, for detailed discussion)

- xxxxx Outstanding recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet many current and future recreation needs, is large enough to accommodate incompatible activities, could link important recreation areas, and/or is close to state's largest population centers.
- xxxx Excellent recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet several current and future recreation needs, is large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to large population centers.
- xxx Very good recreation potential, could offer a variety of land and/or water-based recreation opportunities, could meet some current and future recreation needs, may be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized to large population centers.
- xx Good to moderate recreation potential, could offer some land and/or water-based recreation opportunities, might meet some current and future recreation needs, may not be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized population centers.
- x Limited recreation potential, could offer a few land and/or water-based recreation opportunities, might meet some current and future recreation needs, is not likely large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to small population centers.

Appendix 15.I. *Importance of economic sectors (based on the number of jobs) within the Northern Lake Michigan Coastal counties compared to the rest of the state.*

Industry	CLMC	CSH	CSP	FT	NCF	NES	NH	NLMC	NWL	NWS	SEGP	SLMC	SWS	SCP	WCR	WP
Agriculture, Fishing & Hunting	0.87	2.14	2.41	2.15	2.15	1.90	0.50	2.71	0.43	1.29	0.76	0.10	4.46	0.87	2.36	2.30
Forest Products & Processing	1.64	0.98	1.83	2.40	3.43	2.20	1.33	1.74	0.41	1.07	0.65	0.32	0.45	1.44	0.96	0.69
Mining	1.08	1.64	0.79	0.79	2.69	3.55	0.91	2.16	0.16	0.34	1.47	0.19	0.62	0.08	0.77	1.21
Utilities	2.44	1.08	0.81	0.39	0.61	0.45	0.58	0.41	1.96	1.76	0.67	0.65	0.81	1.83	1.19	0.51
Construction	1.12	1.02	0.89	0.96	1.14	0.92	2.38	1.08	1.07	1.14	1.08	0.67	0.98	1.13	1.03	1.11
Manufacturing (non-wood)	1.23	1.02	0.74	0.98	0.90	1.37	0.21	1.15	0.49	0.59	1.19	0.87	0.78	0.46	0.77	0.99
Wholesale Trade	0.99	0.63	0.61	0.95	0.62	0.53	0.47	0.60	1.15	0.72	1.16	0.98	0.89	0.76	0.83	0.53
Retail Trade	1.01	1.00	0.99	1.11	1.11	1.00	1.66	1.03	1.30	1.19	1.02	0.80	1.69	1.11	1.11	1.13
Tourism	0.99	1.12	0.97	0.86	0.99	1.05	1.51	1.28	1.34	1.41	0.94	1.02	0.78	1.33	1.08	1.12
Transportation & Warehousing	0.95	1.32	2.13	1.40	1.19	1.15	0.80	0.89	3.25	2.15	0.82	0.83	0.74	2.12	1.39	0.99
Information	0.76	0.49	0.69	0.74	0.58	0.68	0.80	0.70	0.38	0.49	1.22	1.11	1.09	0.64	0.62	0.57
Finance & Insurance	1.22	1.31	0.89	0.96	0.56	0.46	0.43	0.48	0.47	0.46	1.04	1.18	0.65	0.45	0.70	0.55
Real Estate, Rental & Leasing	0.84	0.73	0.59	0.60	0.52	0.34	1.37	0.95	0.42	0.50	1.17	1.14	0.47	0.46	0.87	0.66
Pro, Science & Tech Services	0.85	0.53	0.46	0.55	0.41	0.36	0.43	0.45	0.51	0.47	1.04	1.51	0.49	0.47	0.63	0.81
Management	0.80	0.26	0.63	0.54	0.37	0.21	0.17	0.24	0.65	0.47	0.94	1.62	0.08	0.64	0.87	0.45
Admin, Support, Waste, & Remediation	0.99	0.42	0.43	0.46	0.34	0.23	0.61	0.34	0.61	0.43	0.92	1.64	0.58	0.51	0.70	0.63
Private Education	0.86	0.68	0.39	0.42	0.86	0.72	0.87	0.55	0.08	0.12	0.80	1.94	0.09	1.53	0.68	0.55
Health Care & Social Services	0.85	0.88	1.27	1.04	0.82	0.90	0.87	0.84	0.96	0.91	0.83	1.32	0.84	0.99	1.09	0.94
Other Services	1.08	1.32	1.10	1.05	1.10	1.13	1.25	1.19	1.36	1.09	1.06	0.84	1.14	1.13	0.91	1.29
Government	0.78	1.09	1.11	1.03	1.26	1.36	1.08	1.03	1.36	1.54	1.04	0.89	1.15	1.50	1.14	1.21

Source: Based on an economic base analysis (Quintero 2007). Definitions of economic sectors can be found at the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

Appendix 15.J. *Scientific names of species mentioned in the text.*

Common Name	Scientific Name
Alder	*Alnus* spp.
Alewife	*Alosa pseudoharengus*
American basswood	*Tilia americana*
American beaver	*Castor canandensis*
American beech	*Fagus grandifolia*
American black bear	*Ursus americanus*
American elm	*Ulmus americana*
American sea-rocket	*Cakile edentula*
American White Pelican[a]	*Pelecanus erythrorhynchos*
Annosum root rot fungus	*Heterobasidion annosum*
Arrowheads	*Sagittaria* spp.
Arrowhead spiketail	*Cordulegaster obliqua*
Ashes	*Fraxinus* spp.
Aspens	*Populus* spp.
Bald Eagle	*Haliaeetus leucocephalus*
Balsam fir	*Abies balsamea*
Balsam poplar	*Populus balsamifera*
Banded killifish	*Fundulus diaphanus*
Barn Owl	*Tyto alba*
Beech scale insect	*Cryptococcus fagisuga*
Bigtooth aspen	*Populus grandidentata*
Bird's-eye primrose	*Primula mistassinica*
Black ash	*Fraxinus nigra*
Black Scoter	*Melanitta americana*
Black spruce	*Picea mariana*
Black striate	*Striatura ferrea*
Black-crowned Night Heron	*Nycticorax nycticorax*
Blanding's turtle	*Emydoidea blandingii*
Bloater chub	*Coregonus hoyi*
Bluegill	*Lepomis macrochirus*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-winged Teal	*Anas discors*
Bobcat	*Lynx rufus*
Bobolink	*Dolichonyx oryzivorus*
Broad-leaf sedge	*Carex platyphylla*
Broad-leaved cat-tail	*Typha latifolia*
Bronze birch borer	*Agrilus anxius*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Buckhorn mussel	*Tritogonia verrucosa*
Bulrushes	*Schoenoplectus* spp., *Scirpus* spp.
Bur-reeds	*Sparganium* spp.
Caenid mayfly	*Brachycercus prudens*
Canada Warbler	*Cardellina canadensis,* listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List
Canada yew	*Taxus canadensis*
Caspian Tern	*Hydroprogne caspia,* listed as *Sterna Caspia* on the Wisconsin Natural Heritage Working List
Cerulean Warbler	*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List
Cherrystone drop	*Hendersonia occulta*
Chilean sweet cicely	*Osmorhiza berteroi*
Chinook salmon	*Oncorhynchus tschawytscha*
Cisco ("lake herring")	*Coregonus artedi*
Climbing fumitory	*Adlumia fungosa*

Continued on next page

Appendix 15.J, *continued.*

Common name	Scientific name
Coho salmon	*Oncorhynchus kisutch*
Coliform bacteria	*Escherichia coli*
Common bog arrow-grass	*Triglochin maritima*
Common buckthorn	*Rhamnus cathartica*
Common carp	*Cyprinus carpio*
Common Goldeneye	*Bucephala clangula*
Common Merganser	*Mergus merganser*
Common reed	*Phragmites australis*
Common Tern	*Sterna hirundo*
Dame's rocket	*Hesperis matronalis*
Deepwater cisco	*Coregonus johannae*
Dentate supercoil terrestrial snail	*Paravitrea multidentata*
Dogwoods	*Cornus* spp.
Dorcas copper	*Lycaena dorcas*
Double-crested Cormorant	*Phalacrocorax auritus*
Dune goldenrod	*Solidago simplex* var. *gillmann*
Dune thistle (Pitcher's thistle)	*Cirsium pitcheri*
Dutch elm disease fungus	*Ophiostoma ulmi*
Dwarf lake iris	*Iris lacustris*
Earthworms	*Family Lumbricidae*
Eastern cottonwood	*Populus deltoides*
Eastern hemlock	*Tsuga canadensis*
Eastern Meadowlark	*Sturnella magna*
Eastern red bat	*Lasiurus borealis*
Eastern ribbonsnake	*Thamnophis sauritus*
Eastern white pine	*Pinus strobus*
Elegant spreadwing damselfly	*Lestes inaequalis*
Elktoe mussel	*Alasmidonta marginata*
Elms	*Ulmus* spp.
Elusive clubtail dragonfly	*Stylurus notatus*
Emerald ash borer	*Agrilus planipennis*
Eurasian honeysuckles	*Lonicera tatarica*, *L. morrowii*
Eurasian water-milfoil	*Myriophyllum spicatum*
European swamp thistle	*Cirsium palustre*
Forest tent caterpillar	*Malacosoma disstria*
Forster's Tern	*Sterna forsteri*
Four-toed salamander	*Hemidactylium scutatum*
Diplodia pine blight fungus	*Diplodia pinea*
Aspen hypoxylon canker fungus	*Hypoxylon mammatum*
Pocket mortality fungal species	*Leptographium terrebrantis* and *L. procerum*
Beech bark disease fungus	*Nectria coccinea* var. *faginata* and *Nectria galligena*
Aspen heart rot fungus	*Phellinus tremulae*
Garlic mustard	*Alliaria petiolata*
Giant pine-drops	*Pterospora andromedea*
Glossy buckthorn	*Rhamnus frangula*
Golden-crowned Kinglet	*Regulus satrapa*
Golden-winged Warbler	*Vermivora chrysoptera*
Gray wolf	*Canis lupus*
Great Black-backed Gull	*Larus marinus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Greater redhorse	*Moxostoma valenciennesi*
Greater Scaup	*Aythya marila*
Green algae	*Cladophora* spp.
Green ash	*Fraxinus pennsylvanica*

Appendix 15.J, *continued.*

Common name	Scientific name
Gypsy moth	*Lymantria dispar*
Heart-leaf foam-flower	*Tiarella cordifolia*
Henslow's Sparrow	*Ammodramus henslowii*
Herring Gull	*Larus argentatus*
Hine's emerald dragonfly	*Somatochlora hineana*
Hooded Warbler	*Setophaga citrina,* listed as *Wilsonia citrina* on the Wisconsin Natural Heritage Working List
Hybrid cat-tail	*Typha* x *glauca*
Jack pine	*Pinus banksiana*
Kalm's (or shrubby) St. John's-wort	*Hypericum kalmianum*
Kalm's lobelia	*Lobelia kalmii*
Kiyi	*Coregonus kiyi*
Lake cress	*Armoracia lacustris*
Lake Huron locust	*Trimerotropis huroniana*
Lake Huron tansy	*Tanacetum huronense*
Lake sturgeon	*Acipenser fulvescens*
Lake trout	*Salvelinus namaycush*
Lake whitefish	*Coregonus clupeaformis*
Leafy spurge	*Euphorbia esula*
Lesser fringed gentian	*Gentianopsis procera*
Livid sedge	*Carex livida*
Loggerhead Shrike	*Lanius ludovicianus*
Longear sunfish	*Lepomis megalotis*
Long-spurred violet	*Viola rostrata*
Long-tailed Duck	*Clangula hyemalis*
Lyme grass	*Leymus arenarius*
Mare's tail	*Hippuris vulgaris*
Marsh mermaid-weed	*Proserpinaca palustris*
Merlin	*Falco columbarius*
Midwest Pleistocene vertigo terrestrial snail	*Vertigo hubrichti*
Mink frog	*Lithobates septentrionalis*
Muskellunge	*Esox masquinongy*
Mystery vertigo terrestrial snail	*Vertigo paradoxa*
Narrow-leaved cat-tail	*Typha angustifolia*
Nashville Warbler	*Oreothlypis ruficapilla*
North American river otter	*Lontra canadensis*
Northern comandra	*Geocaulon lividum*
Northern cricket frog	*Acris crepitans*
Northern Goshawk	*Accipiter gentilis*
Northern pike	*Esox lucius*
Northern red oak	*Quercus rubra*
Northern Waterthrush	*Parkesia noveboracensis*
Northern white-cedar	*Thuja occidentalis*
Oak	*Quercus* spp.
Oak wilt fungus	*Ceratocystis fagacearum*
Ohio goldenrod	*Solidago ohioensis*
Osprey	*Pandion haliaetus*
Paddlefish	*Polyodon spathula*
Pines	*Pinus* spp.
Pine sawfly	*Diprion* spp. and *Neodiprion* spp.
Piping Plover	*Charadrius melodus*
Pugnose shiner	*Notropis anogenus*
Purple loosestrife	*Lythrum salicaria*
Pygmy snaketail dragonfly	*Ophiogomphus howei*
Quagga mussel	*Dreissena bugensis*

Continued on next page

Appendix 9.J, *continued.*

Common name	Scientific name
Rainbow smelt	*Osmerus mordax*
Rainbow trout	*Oncorhynchus mykiss*
Ram's-head lady's-slipper	*Cypripedium arientinum*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Red-breasted Merganser	*Mergus serrator*
Red-breasted Nuthatch	*Sitta canadensis*
Redfin shiner	*Lythrurus umbratilis*
Red-necked Grebe	*Podiceps grisegena*
Red-shouldered Hawk	*Buteo lineatus*
Reed canary grass	*Phalaris arundinacea*
Ring-billed Gull	*Larus delawarensis*
River redhorse	*Moxostoma carinatum*
Rock whitlow-grass	*Draba arabisans*
Round goby	*Neogobius melanostomus*
Round pigtoe mussel	*Pleurobema sintoxia*
Ruffed Grouse	*Bonasa umbellus*
Rusty crayfish	*Orconectes rusticus*
Salamander mussel	*Simpsonaias ambigua*
Sand-reed grass	*Calamovilfa longifolia* var. *magna*
Sea lamprey	*Petromyzon marinus*
Seaside spurge	*Chamaesyce polygonifolia,* listed as *Euphorbia polygonifolia* on the Wisconsin Natural Heritage Working List
Shining lady's-tresses	*Spiranthes lucida*
Shoal chub	*Macrhybopsis hyostoma*
Shortjaw cisco	*Coregonus zenithicus*
Shortnose cisco	*Coregonus reighardi*
Shrubby cinquefoil	*Pentaphylloides floribunda*
Siberian elm	*Ulmus pumila*
Silver maple	*Acer saccharinum*
Silver-weed	*Argentina anserina*
Six-whorl vertigo	*Vertigo morsei*
Slaty skimmer	*Libellula incesta*
Slender bog arrow-grass	*Triglochin palustre*
Slender-leaved sundew	*Drosera linearis*
Slippershell mussel	*Alasmidonta viridis*
Smallmouth bass	*Micropterus dolomieu*
Snowy Egret	*Egretta thula*
Snuffbox mussel	*Epioblasma triquetra*
Spiny water flea	*Bythotrephes cederstroemi*
Spoonhead sculpin	*Cottus ricei*
Spoon-leaf moonwort	*Botrychium spathulatum*
Spotted knapweed	*Centaurea biebersteinii*
Sticky false-asphodel	*Triantha glutinosa,* listed as *Tofieldia glutinosa* on the Wisconsin Natural Heritage Working List
Striped maple	*Acer pensylvanicum*
Stygian shadowfly	*Neurocordulia yamaskanensis*
Sugar maple	*Acer saccharum*
Surf Scoter	*Melanitta perspicillata*
Swamp darner dragonfly	*Epiaeschna heros*
Swamp metalmark butterfly	*Calephelis muticum*
Tamarack	*Larix laricina*
Two-lined chestnut borer	*Agrilus bilineatus*
Tufted bulrush	*Trichophorum cespitosum,* listed as *Scirpus cespitosus* on the Wisconsin Natural Heritage Working List

Appendix 9.J, *continued.*

Common name	Scientific name
Upland Sandpiper	*Bartramia longicauda*
Walleye	*Sander vitreus*
Western sand darter	*Ammocrypta clara*
White ash	*Fraxinus americana*
White birch	*Betula papyrifera*
White perch	*Morone americana*
White pine blister rust fungus	*Cronartium ribicola*
White River crayfish	*Procambarus acutus*
White spruce	*Picea glauca*
White-tailed deer	*Odocoileus virginianus*
White-throated Sparrow	*Zonotrichia albicollis*
White-winged Scoter	*Melanitta fusca*
Wild rice	*Zizania* spp.
Willows	*Salix* spp.
Winter Wren	*Troglodytes hiemalis*
Wolf's spikerush	*Eleocharis wolfii*
Wood Duck	*Aix sponsa*
Wood turtle	*Glyptemys insculpta*
Yellow birch	*Betula alleghaniensis*
Yellow perch	*Perca flavescens*
Yellow Rail	*Coturnicops noveboracensis*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Zebra mussel	*Dreissena polymorpha*

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 15.K. *Maps of important physical, ecological, and aquatic features within the Northern Lake Michigan Coastal Ecological Landscape.*

- Vegetation of the Northern Lake Michigan Coastal Ecological Landscape in the Mid-1800s
- Land Cover of the Northern Lake Michigan Coastal Ecological Landscape in the Mid-1800s
- Landtype Associations (LTAs) of the Northern Lake Michigan Coastal Ecological Landscape
- Public Land Ownership, Easements, and Private Land Enrolled in Forest Tax Programs in the Northern Lake Michigan Coastal Ecological Landscape
- Ecologically Significant Places of the Northern Lake Michigan Coastal Ecological Landscape
- Exceptional and Outstanding Resource Waters and 303(d) Degraded Waters of the Northern Lake Michigan Coastal Ecological Landscape
- Dams of the Northern Lake Michigan Coastal Ecological Landscape
- WISCLAND Land Cover (1992) of the Northern Lake Michigan Coastal Ecological Landscape
- Soil Regions of the Northern Lake Michigan Coastal Ecological Landscape
- Relative Tree Density of the Northern Lake Michigan Coastal Ecological Landscape in the Mid-1800s
- Population Density, Cities, and Transportation of the Northern Lake Michigan Coastal Ecological Landscape

Note: Go to http://dnr.wi.gov/topic/landscapes/index.asp?mode=detail&Landscape=14 and click the "maps" tab.

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